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THE HAWAIIAN GOOSE (NENE) RESTORATION PROGRAM

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The near extinction of the Nene (*Branta sandvicensis*) was first brought to the attention of wildlife managers and others interested in ornithology by Baldwin (1945) in his article dealing specifically with the reduction of the Nene's range in Hawaii. As a result of Baldwin's investigations, the Nene population in 1944 was placed at less than 50 geese existing in a range reduced from 2,925 square miles on Maui and Hawaii to 1,150 square miles on only the island of Hawaii.

The sad plight of the Nene was even more forcefully presented in 1949 by Charles and Elizabeth Schwartz who spent many months in Hawaii compiling a report on the Hawaiian game birds for the Territorial Board of Agriculture and Forestry. They summarized the Nene conservation problem and the apathy attending its solution in the following very strong and pointed statement in their report, "An immediate study should be undertaken of this bird's life history and means of survival. This wild fowl is the next Hawaiian, if not world, species facing imminent extinction. To permit this tragedy to occur without exerting more effort than has been done to date is unpardonable."

Time for the Hawaiian Goose seems to be rapidly running out. It is appropriate, therefore, to emphasize that the Hawaiian Goose population today is even less than it was in 1944 and in 1947 when Baldwin and the Schwartzes made their field studies. Within the last three years, Nene have failed to return to certain locations that until recently were apparently highly preferred parts of their habitat. In 1944 Nene could be found consistently on the Puu Waawaa Ranch on the slopes of Mt. Hualalai on Hawaii. They nested there, and young were seen frequently. The birds have now vanished from this specific locality and also from the entire Hualalai—North Kona region, all within the past several years. Although Nene were certainly not common, ranch hands during their fence patrol work usually saw at least a few geese in the years prior to 1949; however, in the last three years these same persons covering the same routes in the same manner have seen no geese.

In the Kau Territorial Forest Reserve on Mauna Loa, there is an area at an elevation of 6,500 feet dotted with small, shallow, permanent pools and covered with an open ohia (*Metrosideros collina*) forest with a ground cover of lush grass and sedges. On maps of Hawaii, this area is labeled Kipuka Nene, a name given it by the ancient Hawaiians testifying to its habitation by Nene for centuries. (Kipuka means

an isolated patch of vegetation surrounded by recent lava flows.) In former years, the forest rangers frequently saw geese in this location during patrols in the winter months. In 1948, a ranger saw a flock of 17 Nene, and in January 1949, three were observed. Since then, no Nene has been seen, yet the ranger has continued to make his monthly patrols in the same routine manner.

Despite an active publicity campaign in the last two years to acquaint the people of the Territory with the scarcity of the Hawaiian Goose and need for protecting it, sight reports of the Nene have dropped off to only one or two a year. In 1949, a group of five Nene was reported seen in the Hawaii National Park by the park superintendent. In December 1949, two adult geese were seen by hunters on a cinder cone in the Mauna Loa Forest Reserve. In 1950, a Nene family group consisting of two goslings and one adult was seen near the eastern boundary of the National Park by a reliable observer. Also, that year, a forest ranger reported two adult Hawaiian geese along the Puu Oo trail in the Saddle Region of Hawaii. A most interesting report was received in 1950 of three adult Nene being seen on the island of Molokai. This was immediately followed up by Mr. J. Medeiros, Territorial Wildlife Biologist, who relocated the geese and positively identified them. To date in 1951, three geese were reported in May, and in June, a flock of 7 was seen briefly near the eastern boundary of the National Park at the 6,500-foot level.

While it is true that no systematic count of the Hawaiian Goose has been made, on the basis of a continued constriction of its range since 1949 and the drop in sight report frequency, the population of wild Nene today can hardly exceed 30 birds. The startling drop in its number during the past few years probably is an indication that unless something is done to aid the geese, the existence of the species in a wild state will soon be only a memory.

Attempting to save the Nene from extinction is a worthy cause both from the sentimental standpoint of preserving an irreplaceable creation of nature and from the practical basis of preserving something of "Old Hawaii" for the education of tourists and local residents alike. It is doubtful that the Nene will ever be hunted as a game bird again and to justify restoration attempts with that objective would be misleading to the extreme. The degree of effort made in the past to restore the Nene was surprisingly great and is unknown to many. Artificial propagation of the Hawaiian Goose has been conducted continuously to some degree for over one hundred years in several widely separated countries and is continuing today.

Delacour (1949) states that Nene were first brought to Europe in 1823 and were successfully raised at Lord Derby's estate in Knowsley, England. After this, the geese were distributed to zoos and private collections and became fairly common in Europe. They became scarce again after 1900 and eventually disappeared entirely. Delacour had the last European specimen at his collection at Cleres, France. This was a gander hatched at F. E. Blaau's estate in Holland forty-two years prior to its acquisition by Delacour. This Nene vanished from Cleres at the time of the German invasion of France in 1940 thus

ending over a hundred years' experience of Nene propagation in Europe.

The Board of Agriculture and Forestry became interested in establishing a captive flock of Hawaiian geese in 1927. In that year they received a pair from Mr. Leighton Hind of Puu Waawaa Ranch and placed the birds under wire at the Territorial Game Farm on Oahu. In the next six years, four additional pairs of adult geese were given the Board by both Mr. L. Hind and Mr. Herbert Shipman of Hilo. By 1935 this flock had grown to 42 geese. According to records on file, little difficulty was experienced in the care of the flock.

In 1935, the Board decided to break up this flock because of fear that disease would wipe it out. Accordingly, birds were sent to various sugar and pineapple plantation managers and territorial senators. Ostensibly, the objectives were not only to avert a disaster occurring to the captive birds, but also to stimulate interest in the Nene and to establish many small captive Nene flocks from which breeding stock would always be available should the Board again decide to raise Nene under wire. The plan was a distinct failure. It is suspected that political consideration entered into the decision to distribute the Board's flock about the Territory.

In 1950, a follow up was made on all of the 42 Nene sent out from the game farm in 1935 and 1936. Only one gander remained available to the Board. This was one of a pair given to the Honolulu Zoo. All the others had either died very soon after their receipt or had been released.

One wealthy rancher on Molokai who was given four pairs, had a large pen constructed very similar to the Pahakuloa pen and hired special personnel to care for the geese. The Nene did not lay the first year; so he released them all. This may be the origin of the three Nene observed on Molokai in 1950, although where they had been during the intervening fourteen-year period is a mystery. None of the birds was banded at the game farm before they were shipped out; consequently, the age of the birds given to this rancher was apparently unknown. Since the Hawaiian Goose does not breed until its second or third year, the Molokai flock might well have been composed of first and second year birds. Under those circumstances, production the first season on Molokai in a new environment would have been most unusual. It is a pity that this flock was released to the wild so prematurely and on an island which was never occupied by the Hawaiian Goose, at least in historic times.

Fourteen geese went to a wealthy senator and were penned at his beach home near Kawaihae, Hawaii. These were retained for several years at sea level with no young produced. At last they, too, were released to the wild. It is to be hoped that this group joined the wild flocks on Hualalai; however, since they were not marked in any way, the valuable knowledge of their movements will never be obtained.

Six Nene were presented to a wealthy philanthropist who maintained a menagerie on his own private island near Oahu. The history of these geese is absolutely unknown, for after the death of the island's owner, his estate was disposed of and no one seems to know whether the geese were released or given away.

One other example will suffice. Three geese, one gander and two geese, were sent to the pineapple plantation manager on Lanai. These were immediately released and were seen for one month thereafter. They were very tame and easily approached. The person who released the birds has good reason to believe that Filipino laborers captured the geese for food, thus, ending this dark chapter in the story of one ill-fated attempt to restore the Nene in Hawaii.

At present three projects are underway which will probably extend the life of the Nene as a species, but none of them contains all of the basic requirements of a sound Nene conservation program. These projects are a Nene farm started in 1949 by the Board of Commissioners of Agriculture and Forestry, a similar venture established by the Severn Wildfowl Trust at Slimbridge, England, and a Nene flock maintained by Mr. Herbert Shipman at Keaau, Hawaii. The first two of these projects are new and appear worthy of some discussion since they apparently mark the real beginning of an action program designed to benefit the Nene and are a rather astonishing manifestation of the wide interest in the Nene conservation problem. Neither of the two new projects, however, could have been undertaken had Mr. Shipman not taken a personal interest by supplying the initial breeding pairs.

For many years a flock of Hawaiian geese was kept in a semi-captive condition by Mr. Shipman, a well-known Hawaiian rancher, at his estate near Hilo, Hawaii. This flock fared well at times and badly at others. From two pairs in 1918 his flock grew to 42 birds; however, various tragedies occurred, including an engulfment of the entire estate by a tidal wave, reducing the flock to a remnant of 11 birds in 1949.

The Schwartzes suggested in their report that a few pairs of Nene be obtained from Mr. Shipman and established in pens under the control of the Board of Agriculture and Forestry where they could receive the best of scientific care.

This suggestion was carried out, and in August, 1949, two pairs of Nene were obtained on loan from the Shipman estate and placed in pens at Pohakuloa, Hawaii. This small flock was increased in 1950 with the addition of a third pair composed of a gander loaned by the Honolulu Zoo and a wild-caught goose.

The Nene pen at Pohakuloa is of two adjacent sections 50′ x 100′, covered top and sides by one-inch mesh fox farm wire. A three-foot wide strip of sheet iron extends around the bottom of the pen on the exterior to prevent mongoose from climbing the wire. Pools 15 feet square, shallow at one end, and 2½ feet deep at the other were constructed in the center of each pen. After heavy fertilizing and constant watering, a heavy stand of white clover (*Trifolium repens*) and Kikuyu grass (*Pennisetum clandestinum*) was induced to grow on the very sandy and porous soil within the pens.

The consistent bad temper of the ganders, even more pronounced during the breeding season, makes segregation necessary, so the pairs are kept in separate pens. With supplementary feeding it is possible to maintain a pair on 1,250 square feet of pen area without a noticeable deterioration of the grass and clover sod. With present facilities

there is enough pen space to care for eight pairs of geese. As the flock grows, some crowding may have to be done, although this is definitely not desirable.

The geese have been fed several different kinds of grains, prepared mashes, and turkey pellets. They have shown a decided preference for whole wheat soaked in water before feeding. They will peck at the mash and seem to take the corn fairly readily, but hardly touch the turkey pellets.

Other foods that they avidly devour and which are fed daily include pualele, the common sow thistle (*Sonchus oleraceus*). A bed of water cress is maintained by overflow from water storage tanks near the Nene pens, and these greens are fed as an alternate to the pualele. Noteworthy, is the decided preference shown by the geese of all ages from downy young to old doughty ganders for the sow thistle. It is amusing to watch the birds follow the game keeper about the pen anxiously waiting for him to deposit his armload of "weeds" in their feeders. Quite frequently an armload is devoured by a family group of two adults and three goslings in an hour's time. Baldwin (1947) claims this plant was previously considered an important food plant but since the Nene have been largely extirpated from the low-land ranges, it is no longer available to the geese in quantity. It is most abundant around the ranch and farm areas below 4,000 feet and is uncommon in the present main range of the Nene. Curiously, the pualele is common in the Pohakuloa area at 6,500 feet, which is neither cattle range nor farm land.

The major objective of this propagation venture is to produce 50 geese a year to be released into the wild to restock the natural range. Unfortunately, only one of the captive pairs has been productive and only five goslings have been produced in the two years of the project's operation. During the first breeding season, the goose of the second Shipman pair of Nene did not lay. This bird later died of a massive hemorrhage through a large lung abscess (no tubercular condition noted upon autopsy. The second year, the wild-caught goose laid four eggs, but all proved to be infertile.

In the next breeding season of 1951-52, it is hoped to step up the production rate materially by removing the first clutch from both geese to set under chickens and leaving the second clutch for the goose to incubate. Thus, if this technique is successful, by 1954 the program of releasing Nene into the wild may be started.

A few facts about the Nene's life history gleaned from watching the captive birds might be of interest. Their breeding season begins in November, and the ganders become very pugnacious. Also at this time, there is a decided tendency to fly demonstrated by much wing flapping and leaping about. The geese do not lay until two or three years old. At Pohakuloa the first eggs are laid during mid-December. One egg is laid daily until the clutch is completed. The clutch size varies from three to five eggs. On the basis of the two clutches hatched at Pohakuloa, the incubation period appears to be twenty-eight days. The goslings grow very rapidly, and by nine weeks are as large and heavy as the adults. Incubation is by the goose only; however, it is difficult to imagine a more attentive male of any

species than the Nene gander from the time the first egg is laid until the full-grown goslings are separated from the adults. At Pohakuloa both the gander and the goose moult their primaries in March. By the end of April, the flight feathers have grown out again and wing-clipping is done at this time.

When considering the possible causes of the Nene's decrease in numbers, it would be well to note this flightless condition of adult geese which lasts a month and coincides with the brooding period of the goslings. It means that the entire Nene population is almost hopelessly vulnerable to ground attacks by dogs, pigs or other enemies for at least a month of each year. There are no lakes or marshes on Hawaii which could be used for refuge by the Nene during their flightless period.

The second new Nene restocking project is operating in England under the direction of Peter Scott on the grounds of the Severn Wildfowl Trust at Slimbridge. Mr. John Yealland, curator of the Trust, came to Hawaii in 1950 to help the Board of Agriculture and Forestry project at Pohakuloa. Upon leaving Hawaii, he was presented with a pair of Nene by Mr. Shipman to escort to England. A valuable feature of this restocking project is that it will be insurance against the entire loss of breeding stock due to a possible complete destruction of geese at the Pohakuloa and Keeau, Hawaii, project sites. Another very satisfying consideration is that the personnel caring for the geese at Severn have a special aptitude for raising waterfowl of all species. Not only will this help to insure a successful project, but will probably mean the development of techniques which will aid the Pohakuloa project reach its production objective.

It is believed that an accurate picture is presented in Table 1 of the Nene population existing in the entire world. This probably illustrates better than any other presentation the narrow chasm separating the Nene species from oblivion. The only possible inaccuracy is that inherent in the estimate of the wild population (30 geese). However, even if the population is twice as large as estimated, the number of Hawaiian Geese remaining in the wild is decidedly not comfortably large.

The information about the continued reduction in numbers of wild Nene must be constantly reviewed and emphasized in order to place in proper perspective the present efforts to raise Nene under artificial conditions. The establishment and operation of the present Nene farms is only a partial solution to the problem of averting the Nene's extinction. No

TABLE 1.—DISTRIBUTION OF HAWAIIAN GEESE, 1951

Location	Controlling Agency or Person	Status	
		Captive	Wild
Keaau, Hawaii	Mr. Herbert C. Shipman	11	..
Kealakekua, Hawaii	Mrs. Wall	1	..
Pohakuloa, Hawaii	Board of Agriculture & Forestry	9	..
Island of Hawaii	.....	..	30 (est.)
Slimbridge, England	Severn Wildfowl Trust, Peter Scott, Director	3	..
Island of Molokai	.....	..	3
	Total.....	24	33

matter how successful this phase becomes (and it is very likely that many geese will be produced by this work as they are not difficult to raise) the danger of the Hawaiian Goose becoming extinct will not be removed.

There are two basic reasons for this: (1) the same influences operating against the Nene's survival will continue to affect the Nene released into the wild and perhaps even to a greater extent than on the existing wild birds; and (2) the continuity of the restocking phase at Pohakuloa depends upon the attitude of the successive Commissioners of the Board of Agriculture and Forestry. Since the members of the Board once before successfully raised Nene at their game farm and then discontinued the program after seven years, the example appears to prove that the present venture cannot be considered basically stable. The history of European Nene propagation also demonstrates serious basic shortcomings in the attempts to save the Nene by producing them under wire.

The only effort which is likely to produce lasting and concrete results in conserving the Nene is that directed toward discovering the factors responsible for the Nene's population decline. An ecological study properly conducted of the wild Nene will produce a knowledge of the Nene's life history that no change in attitude of a political agency can affect. It will provide a foundation upon which public service agencies and private organizations can act swiftly and surely either in cooperation or singly to form a Nene conservation program basically sound and continuous in duration and effort.

In May 1951, the Board of Agriculture and Forestry authorized a limited study of the Nene in the wild as a part of the wildlife research program presently being conducted on game birds under Hawaii's Federal Aid Project 5-R-3. This limited study will consist of investigations by a ground party of Nene observations reported to the local office of the Board of Agriculture and Forestry. This same kind of investigation has been done before by Baldwin, Schwartz, and present personnel of the Board's game section without a great deal of satisfactory information being obtained. The problem in the past was a consistent and discouraging inability to find the geese again after they were reported. An important part of the new study will be directed toward setting up a good reporting system and a procedure whereby the ground party of biologists can be on the way in the field following up on sight reports within four hours of their receipt.

The object of the study is not primarily to gather a file of photos of wild Nene but to find out what the Nene are doing in the particular place where sighted. Such items as direction of flight, time of flight, and flight distance will be gathered if possible from the geese under observation. Perhaps, a better count of the geese in the wild will be obtained from this kind of study, although some error will result due to the length of time between observations.

Probably the most valuable result of the study will be to provide a beginning for a more intensive Nene ecological survey to be conducted after the limitations of the present studies have become more apparent.

In the opinion of the writer, a well-

rounded Nene conservation program should consist of three parts: (1) An intensive ecological survey of the Hawaiian Goose found in the wild; (2) the production of Nene under wire by methods through which the productive potential of the geese would be nearly realized by protection and stimulation of maximum egg production; (3) the acquisition, management, and restocking of an area of Nene habitat selected as a result of the ecological survey. Apparently, this entire program is slowly being shaped, and it is hoped that within a few years Hawaii can boast of a sound Nene conservation program that will make possible substantial and rapid progress toward the ultimate objective of building the wild Hawaiian Goose population to a satisfactory level and maintaining that level through intelligent management.

SUMMARY

The wild Nene population in Hawaii has continued to shrink, bringing the present number to an estimated 30 birds. This estimate is based upon desertion of habitat found to be occupied in 1944 and by a reduction in frequency of Nene observations.

Three projects of raising Hawaiian Geese under wire are in operation now with the objective of saving the Nene from extinction. Two of these are located in Hawaii and the third in England.

Attempts to raise Nene under artificial conditions have been made in the past. As early as 1823, Nene were successfully raised in England and in the next seventy-five years became quite common in the zoos and menageries of Europe. By 1900, they had become scarce and the last Nene in Europe, a gander, disappeared from Cleres, France, in 1940.

The Territorial Board of Agriculture and Forestry began raising Nene in 1927. Its flock grew to 42 birds but was broken up in 1935 and the geese distributed to various persons in the islands. All but one Nene had vanished by 1949 when the Board's second project was begun. This bird, a gander, was transferred to the new project for use as a breeder.

At present there are 24 Nene in captivity in addition to the estimated 30 wild geese.

The artificial propagation projects should not be considered adequate to the task of restoring the Nene because of the lack of a certain basic stability. This deficiency is amply illustrated by the fate of previous projects begun with sincerity of purpose but proving to be only temporary and poorly directed.

The effort likely to produce the most valuable and lasting results is that placed in an ecological survey of the Nene in the wild. Such a study is being initiated by the Board of Agriculture and Forestry but it is limited in scope. Its chief value appears to be that it is a beginning and may lead to a more intensive ecological study.

An ideal Nene conservation program is one embodying the ecological study, the artificial propagation projects, and a management program of restocked Nene habitat. Apparently, this type of program is slowly being established in Hawaii and within the next few years some progress may be made toward increasing the Nene in the wild.

PLATE 1. Nene family. Goslings hatched January 23, 1951, and three weeks old when photographed.

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FALL AND WINTER HABITS OF PRAIRIE CHICKENS IN SOUTHWEST NEBRASKA[1]

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The Greater Prairie Chicken, *Tympanuchus cupido americanus* (Reichenbach) was formerly the most abundant game bird in Nebraska. Bent (1932) called the prairie chicken the first ranking game bird of the prairies, but pointed out that the bird's adjustment was not simple and that it needed the help of conservation commissions, sportsmen, and bird lovers to compete with many adverse conditions. Aughey (1878) deplored the slaughter of birds, and estimated that at least 300,000 prairie chickens were shipped out of thirty eastern and southeastern Nebraska counties in 1874.

Besides being popular among sportsmen the prairie chicken was also of considerable economic importance to the settlers. In severe winter weather it often was utilized as food. The prairie chicken aided the farmer by destroying vast numbers of grasshoppers and other insects during the growing season for crops. Aughey (1878) wrote that when locusts invaded the Republican valley of southwestern Nebraska in 1874 the prairie chickens seemed to abandon all other foods and eat nothing but locusts. Little else than locusts were found in stomachs for a month. Judd (1905) found that grasshoppers constituted over 90 per cent of the animal foods taken by prairie chickens.

Esthetic values of this bird were recognized by the prairie farmers. The spring booming and parading antics of the males were an interesting accompaniment to the coming of spring. Residents still look forward annually to this phenomenon in areas where prairie chickens are found.

Prairie chickens were abundant over much of Nebraska in the latter part of the last century and the first two decades of the twentieth century. Since then reduction of suitable habitat through plowing of the prairie, drouth, and grazing, has taken place. With reduction of habitat the chicken population rapidly decreased, until today the bird is considered rare in many counties where

[1] This paper reviews studies which were made in partial fulfillment of the MS degree at Iowa State College. Grateful acknowledgment is made of helpful counsel extended by Dr. George O. Hendrickson while the studies were being made.

it was common in the middle 20's. Closed seasons were in force from 1929 through 1949.

The merits of this species, both as a game bird and as an insect destroyer, make its perpetuation and increase highly desirable. Before management can be satisfactorily accomplished, knowledge of the conditions necessary for natural production of prairie chickens is necessary. It is particularly important to learn how agricultural practices influence the habits of the birds and how these practices may be modified or changed to bring about an environment acceptable to them.

FIELD STUDIES

The chief objective of the studies reviewed here was to obtain information concerning the fall and winter habits of prairie chickens. Particular attention was given to feeding and cover requirements of the birds during the fall and early winter.

Field work, from September, 1940, into January, 1941, centered in the sandhill areas of Chase County, Nebraska, and occasionally extended into Yuma County, Colorado. The first few days in the field were spent in examination of local areas to locate those suitable for intensive observations.

DESCRIPTION OF THE STUDY AREAS

The two areas selected for study are about 32 airline miles from each other. They were chosen largely because they had resident prairie chickens at the time field work was begun. In the early stages of the field investigation, when residents in many parts of the county were being questioned as to recent presence of prairie chickens, they almost invariably mentioned one or the other of these areas. Intensive work on each area covered the land over which the resident fall birds ranged.

Both study areas were located in the sandhills. The rougher parts of the sandhills are gently rolling to billowy. Small, flat valleys, commonly running from northwest to southeast, are interspersed between the more hilly areas. The soil is chiefly fine sand which is susceptible to blowing when not covered by vegetation. Hence, it is utilized principally for grazing. Since the soil is porous and absorbs moisture readily, there is very little surface drainage.

Loamy sands and sandy loams are found in certain areas. Most of the cultivation is confined to these soils. Corn is the most important cultivated crop. Sorghums rank next to corn in acreage. Limited amounts of rye and other small grains are grown.

One area, hereafter referred to as the northeast area (Fig. 1), centered in the southeast part of section 31, Township 8 N, Range 36 W, Chase County. It included approximately 3,000 acres in sections 29, 30, 31 and 32 of Township 8 N, Range 36 W, and sections 5 and 6, Township 7 N, Range 36 W.

In the 36 sections surrounding the northeast area, about 25 per cent of the land was cultivated in 1940. Eleven of these sections had no cultivated land and in 11 others 25 per cent or less was cultivated. Only seven of the 36 sections had over 50 per cent of their area under cultivation. Of the 3,000 acres over which the northeast flock ranged, 35 per cent was cultivated. A block of grass land, comprising 6,400 acres, and continuous excepting for roads and fences, extended south and east from this area.

Another block extending west and south contained 18,610 acres of grass land and but 510 acres of cultivated land.

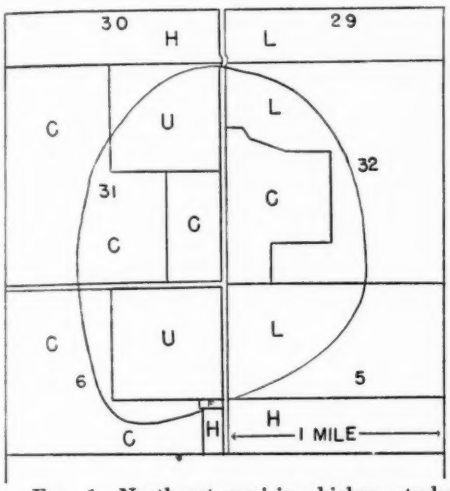

FIG. 1. Northeast prairie chicken study area, Chase County, Nebraska.
U—Ungrazed
L—Lightly grazed
H—Heavily grazed
C—Cultivated
F—Farmstead
Numerals indicate section numbers.
The flock here usually ranged within the oval-shaped area shown.

A small part of the ungrazed northeast quarter of section 6 in this area was formerly cultivated. Cultivation was discontinued by 1930 or earlier and this tract in 1940 was quite uniformly covered by grasses. A 40-acre tract in the northwest quarter of section 5 was cultivated in the early days of settlement but has not been cultivated since about 1905 or earlier, according to long-time residents on adjoining farms. This tract in 1940 was well covered by grasses.

Pasture areas most used by prairie chickens in the northeast area were withheld from grazing during the spring and summer of 1940. These included a 400-acre pasture grazed by 100 cattle from October 15 to November 15, and a 650-acre pasture grazed by 95 cattle and 8 horses during October, November, and December, 1940. Prairie chickens seemed to avoid another pasture of 570 acres which carried 21 cows with their calves, and five horses, throughout the 1940 grazing season.

The second area, hereafter called the southwest area (Fig. 2), centered in the southeast part of section 8, Township 5 N, Range 41 W, Chase County. It included approximately 2,000 acres in sections 8, 9, 16, and 17, Township 5 N, Range 41 W.

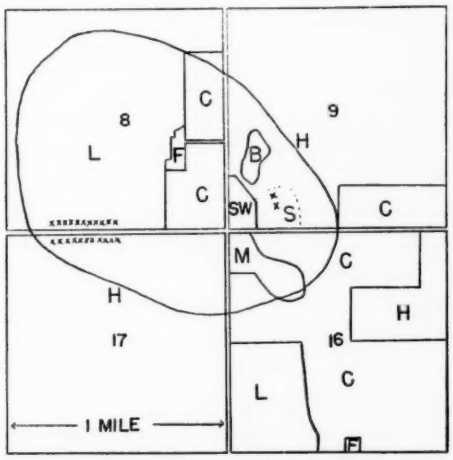

FIG. 2. Southwest prairie chicken study area, Chase County, Nebraska.
L—Lightly grazed
H—Heavily grazed
M—Mowed grass
S—Dense sage area
SW—Weedy sweet clover, uncut
C—Cultivated
B—Sand "blowout"
F—Farmstead
xxx—location of sage measurement plots
Numerals indicate section numbers.
The flock here usually ranged within the oval-shaped area shown.

In the 36 sections surrounding and including the southwest area about 21

percent of the land was cultivated in 1940. Fifteen of these sections had no cultivated land, 10 others had 25 per cent or less under cultivation, and only four sections had over 50 per cent of their area under cultivation. Of the approximately 2,000 acres over which the southwest flock ranged, about 21 per cent was cultivated. In an adjoining block of land of over 26,000 acres only 11 per cent was cultivated. The southwest area had no uncut and ungrazed grassland. A 40-acre tract of prairie hay was cut in September. The grassland used most by prairie chickens during the fall on the southwest area was in an 841-acre pasture which was used during the summer and fall of 1940 by 50 cows, 44 calves, and 8 horses.

PRAIRIE CHICKENS OBSERVED

Prairie chickens were observed in 41 half-day periods between October 17 and December 27. Eighteen of these were early morning and forenoon periods; twenty-three were afternoon and evening periods. Morning observations usually began at or before sunrise and continued at least until the birds left the feeding areas for daytime loafing cover. Afternoon observations usually terminated when the birds went to night roosting places, although on certain occasions later investigations were made at roosting places. Information was recorded concerning number of birds seen, flushing distance, flight distance, fields used for feeding, length of feeding periods, roosting and loafing cover used, disturbances caused by hawks, and activity at the booming ground.

Many of the observations of flocks were made from a car parked near fields in which the birds fed. After the first few observations little effort was made toward concealment because the birds paid little or no attention to a moderate amount of nearby activity. Several observations were made on foot from open locations in fields or pastures. The birds in flight apparently showed no more concern for a parked car than for other familiar objects of the landscape. On several occasions flocks passed over the car at heights of 30 feet or less.

It was found that accurate counts could be made best when prairie chickens were on the wing especially during the soaring part of the flight. At this time the relative positions of individuals in the flock are quite stable. During the periods of wing beating the individual birds appear to shift their positions in the flock in a confusing manner. Counting in fields proved impracticable as only a small part of a flock ever showed itself in a given time. Tracks in light snow on December 27 yielded a satisfactory count, thirty-four sets of tracks were counted going into a cornfield and 35 birds were subsequently flushed about 60 yards from the point where the tracks entered the field.

In the northeast area the average number of birds seen per day increased rather uniformly as the season advanced, 28 in October, 36.5 in November, and 41 in December. A similar increase was found in the size of the flock and in the largest numbers seen in a day. At least 55 chickens occupied the northeast area in December. Yeatter (1943) and others have also noted the fall progress of the flocking tendency.

In the southwest area the average number seen per day was greater in

November (49.1) than in either October (35.1) or December (41.2). At least 54 chickens occupied the southwest area in December. The presence of two flocks on November 23 raised the November average. One flock appeared nervous and did not feed in the unconcerned manner typical of birds at this area. It is probable that this flock was migrating to a winter feeding place and stopped in this area to feed and rest. Charles Schamel (in conversation) reported a similar occurrence on the same area a few days earlier in November. Over and Thoms (1920) observed that, in South Dakota, prairie chickens migrate a few miles to find suitable winter feeding grounds, going into cornfields when snow is on the ground. The State Conservation Commission of Wisconsin (1932) reported that returns from birds banded in 1931 showed a shift from winter to fall of one to three miles, but the same winter feeding grounds were used in succeeding years.

An average of 40.4 chickens were seen at morning observations, while late afternoon observations averaged 33.5 birds. Apparently local populations were more compactly grouped in the morning than later in the day.

Only one prairie chicken was handled during the study. This was a dead chicken found on a public road in September on the southwest area. The bird may have been a victim of auto traffic or it may have struck a nearby wire fence in flight.

FEEDING IN FIELDS

Judd (1905), investigating stomachs of prairie chickens from Nebraska and other states, found corn to be the chief grain eaten. This amounted to 19.45 per cent of the annual food. McAtee and Beal (1917) reported that almost 15 per cent of the prairie chicken diet consisted of weed seeds. Leopold (1933) listed corn as a staple food, eaten mostly after the first snow.

In the Chase County studies regular feeding in fields began during the second week of October, within a few days of the first general frost of the autumn. Cornfields were used for 37 observed feeding periods, Sorghums in shocks 21 times, and rye stubble and Sudan grass in shocks four times each. The birds often alighted on sorghum shocks when entering fields, moving sooner or later into standing corn for the main feeding.

Sorghum shocks were used to the exclusion of corn only once, on December 17, when about 10 inches of snow apparently made cornfield feeding unattractive. Reddish droppings examined at a loafing place on the same date indicated that other recent feedings had also been from sorghum seeds instead of corn. These observations suggest the desirability of leaving some shocked feeds in the field for winter use by the birds.

In the northeast area the field usually selected for feeding consisted of alternate strips of corn and sorghums, with 10 acres of sorghums and 48 acres of corn.

In the southwest area the field used most was standing corn with sorghum shocks nearby. This corn, an 11-acre field, extended to within 200 yards of Charles Schamel's farm buildings. Hogs feeding in this field removed ears of corn from the stalks and left much loose corn available to the birds. The

combination of an abundance of corn on the ground and the nearby location of good roosting cover apparently made this particular field the preferred feeding place.

A feeding flock ordinarily behaved in a carefree manner, although it was noted on several occasions that one individual assumed the appearance of a watchman. When this individual turned to feeding, another member of the flock became alert. The natural coloring of the prairie chicken enabled individuals to hide by the simple expedient of freezing, or remaining motionless.

When observed in fields by stalking, the prairie chickens moved very slowly and carefully. Every effort seemed to go toward blending into the surroundings. The birds made no quick movements at such times unless they actually burst into flight.

During feeding periods individual birds were often observed moving short distances on wing. During such movements the flight was only high enough to clear the tops of the cornstalks. The greatest distance which a feeding flock moved by walking was 240 yards. Usually the point at which a flock took wing on leaving a field was not far from the point where the flock alighted on entering the field.

Coues (1874) mentioned that prairie chickens enter cultivated fields on foot, but in our studies flocks usually flew in. Walking into fields was noticed on clear, warm, spring-like mornings at the southwest area. Individual birds sometimes perched on fence posts or on fence wires for a few minutes when a walking flock approached a fence. On November 1, at the northeast area, 14 birds were observed walking through sorghum stubble towards a cornfield located across the road. Upon nearing the road the flock took wing, moving well towards the center of the field before alighting.

Thirty feeding periods which were timed averaged 82.1 minutes, ranged from 45 minutes to 2.5 hours. Thirteen morning periods averaged 83.3 minutes. Seventeen afternoon periods averaged 81.1 minutes. Periods varied considerably with changing weather conditions and disturbances in the field. Interesting conditions were noted in connection with all feeding periods of less than one hour's duration. On October 23 a morning feeding period of 45 minutes followed a lengthy period of sunning and display. On that date grasshoppers were still available as food in pasture lands. On November 1, with grasshoppers again available on a warm day when the temperature reached 73 degrees Fahrenheit, the afternoon feeding period was of 53 minutes duration. On December 17, a flock fed 45 minutes on sorghum shocks. The direction of flight in approaching this field indicated that these birds had been using winter wheat before going to the shocks. On December 19, a 50-minute period terminated when a hawk approached the feeding place.

Morning feeding usually began shortly after sunrise. However, on December 21, with snow on the ground and in bright moonlight, a flock of prairie chickens on the southwest area flew into a cornfield 47 minutes before sunrise.

According to Charles Schamel (conversation), the flock on the southwest area feeds in the pasture in late winter, following the wagon when sorghum forage is thrown onto the ground for livestock. The birds do not begin this pasture feeding until after waste corn

has been gleaned from the hand-picked fields. In the winter of 1940-41 the last corn was picked late in December, sorghum shocks remained available throughout the winter, and prairie chickens first fed behind the wagon with the livestock on February 14.

Nelson (1939) stated that prairie chickens returned to meadows at night. In the present investigation flocks flew from fields to roosting places 24.6 minutes after sunset, the average based on 17 such flights. The longest interval recorded was 33 minutes and only three of the 17 intervals were shorter than 22 minutes.

LOAFING AND ROOSTING

Daytime resting or loafing, and night roosting, may be treated together since prairie chickens used the same cover for both purposes.

Mixed stands of prairie grasses occupied the uncultivated parts of both study areas. Sand reedgrass (*Calamovilfa longifolia*), little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon furcatus*), and buffalo grass (*Buchloe dactyloides*) were important grasses on both areas. Sand reedgrass was the most widely distributed tall grass on each area. Smaller amounts of switch grass (*Panicum virgatum*), blue grama (*Bouteloua gracilis*), and wild rye (*Elymus canadensis*) grew on both areas. In addition to the above grasses sand dropseed (*Sporobolus cryptandrus*) was one of the three most common grasses on the northeast area. Sage brush (*Artemisia* spp.) was common in pastures of the southwest area. It was present but rare on the northeast area. The yucca (*Yucca glauca*), called soapweed by most Nebraskans, occupied certain ridges on the northeast area but was unimportant excepting for small localized areas.

Typical loafing and roosting cover on both study areas consisted of stands of mixed grasses having (1) numerous stems over two feet in height, (2) fairly dense cover extending from one to two feet above the ground, and (3) a dense understory of fallen and tangled grasses covering the ground to a depth of eight inches or more.

Heavily grazed pastures within the study areas were noticeably deficient in tall grass cover and had but little understory; prairie chickens avoided such areas. Some closely grazed plots had few tall stems excepting weed and grama stems, neither of which provided good protective cover for birds.

The main roosting and loafing cover on the southwest area was on the Schamel ranch in a pasture which joined cultivated fields in section 8. Roosting cover in this pasture consisted of an interspersion of sage brush and tall prairie grasses. The most common tall grass was sand reedgrass. Sage here averaged one clump per 26 square yards in 11 measured plots totalling 4,400 square yards. When the flock used another field for about two weeks in December, a roosting place in section 9 near the temporary feeding place was utilized. The roosting cover used during the two weeks period differed from the regular roosting cover in having a denser stand of sage brush, which occurred in a density of about one clump per three square yards in two plots totalling 800 square yards. Upon moving back to the Schamel field the birds used the original roosting cover through the winter.

Although prairie chickens often flew

over part of section 17 they did not alight there and no droppings were found there. The favorite roosting area was, however, immediately across the fenced right-of-way in adjoining section 8. Observations indicated that section 17 was unattractive to prairie chickens largely because of its lack of tall grasses and absence of an understory of tangled grasses. Section 17 had sage brush averaging one clump per 18 square yards in 11 measured plots totalling 4,400 square yards. The sage clumps averaged about 20 inches in height, with a similar diameter.

Prairie chickens apparently prefer grassy cover to sage; the condition of the grass is probably more important than sage in determining habitability of a local area by prairie chickens. This is not surprising since most of North America's chicken range is east of the sage country. Only temporary or short-time use of dense sage cover was noted during the study.

In the northeast area four different tracts of grassland were located within a half-mile of the main feeding area. All four of these were used for both loafing and roosting at some time during the course of the investigation. Two of these were 160-acre plots on which no grazing was permitted in 1940. Both were unfenced and for many years have been used irregularly as sources of wild hay crops. The third plot contained 400 acres and was pastured at the rate of one head of livestock per four acres for one month in the fall. The fourth plot, another pasture, contained 650 acres and was grazed at the rate of one head of livestock per six acres during October, November, and December. Sand dropseed was found in dense stands in places which had previously been cultivated. One of these dropseed areas was included in a pasture but the livestock spent little time there; grazing animals seemed to prefer the places where other grasses predominated.

Prairie chickens on the northeast area shifted their roosting and loafing places somewhat as winter conditions succeeded fall conditions. The trend of such shifting was from pastured areas towards ungrazed stands of grasses of the bunch-grass type such as little bluestem and sand dropseed.

In December the NE¼ of section 6, an ungrazed tract, became increasingly important for loafing and roosting purposes. Sand dropseed and little bluestem occupied much of this tract. Both of these grasses form bunches. On this tract there were comparatively few stems over two feet in height. However, the bunches of grasses were uniformly spaced and most of the stems reached 20 inches in height, providing good concealment cover and protection from the wind.

On the northeast area prairie chickens frequently used the NE¼ of section 31 and the NW¼ of section 32 for roosting and loafing. They were not known to use the adjoining SE¼ of section 30. In an attempt to learn whether or not grazing had affected the habitability of these areas stem counts were made. Only those stems above two feet in height were counted and a notation made as to the height or quality of the understory. This method was based upon the observation that, on the southwest area, prairie chickens did not utilize grass for roosting or resting unless some 2-foot stems were present.

Walking across the NW¼ of section

32, the SE¼ of section 30, and the NE¼ of section 31, stems in 143 individual plots of one square yard each, taken at twenty yard intervals, were measured and counted.

The NE¼ of section 31 was ungrazed, and it had more tall stems than the nearby grazed areas. 46 plots here had an average of 7.9 stems over 2 feet tall per square yard and an average height of understory of 8.3 inches. This area was used steadily by prairie chickens for loafing and roosting, and only two percent of the plots lacked an understory. To state it differently, prairie chickens alighting here had 98 chances in 100 of striking a plot with protective ground cover.

The NW¼ of section 32 was grazed at the rate of one head of livestock per 4 acres for one fall month. 53 plots here averaged 6.0 stems over two feet tall per square yard. The understory averaged 8.7 inches in height, and only 6 per cent of the plots lacked an understory. This pasture was also used regularly by prairie chickens.

The SE¼ of section 30 was grazed at the rate of one head of livestock per 12 acres for the entire season. 44 plots here averaged 5.7 stems over two feet tall per square yard. However, the understory here averaged only 4.5 inches in height and 48 per cent of the plots lacked an understory. This area was not used by prairie chickens.

A considerable part of the stems of section 31 were sand dropseed, a species which averages less than two feet in height. Tall stems in sections 30 and 32 were mostly sand reedgrass, a species which commonly exceeds three feet in height. Hence, tall stem averages were kept closer together by the presence of a shorter grass representative on the ungrazed plot. The difference of 0.4 inches in average height of understory by which section 32 exceeded section 31 was probably likewise due to a greater abundance of sand dropseed on section 31. Sand dropseed is bunchy in character and does not have a strong tendency towards the formation of an understory of fallen and tangled grasses in fall and early winter.

That prairie chickens avoided section 30 because of the scanty understory cannot be definitely concluded. Its greater distance from the cornfield feeding area may also have been a factor in discouraging the use of section 30. A similar situation probably operated in section 5, where the north half-section was used as daytime loafing cover while the birds were never seen in the south half. The north half offered good grass cover to the height of two feet while cover in the heavily grazed south half was spotty, with larger patches of bare sod than of useful cover.

It appears that both the quality of roosting cover and its proximity to suitable feed may be factors in determining the winter home range of prairie chickens. This was noted earlier by Schmidt (1936). He believed that roost cover and food determine what range is habitable by Wisconsin prairie chickens in winter.

Summarizing the evidence reviewed above, four conclusions seem in order concerning grazing, as follows:

(1) Ungrazed or partially grazed grassland provides more ground cover than land grazed throughout the season.

(2) Control of grazing is necessary if maximum habitat qualities

are to be maintained for prairie chickens.

(3) Grasses such as sand dropseed, which ordinarily provide little ground cover in grazed areas, may become useful to prairie chickens when protected from grazing.

(4) Considerable time will be required to bring back good habitat in areas now lacking in quality because of past abuse or disturbance.

The distance from night roosting places to feeding places varied from one-eighth to three-fourths of a mile. Nelson (1939) stated that the cruising range to cornfields in the daytime may be several miles.

The accumulation of droppings at roosting sites indicated that several birds roost within a few yards of each other. Compact groups apparently were not formed for roosting.

On warm fall days fresh droppings were frequently noticed on the shady side of sage and grass clumps, indicating the birds' use of shady locations for loafing. On two extremely windy days in October flocks remained in cornfields through the middle of the day. Several birds were seen in dust baths in locations which afforded some protection from the wind. In mid-December, when deep snow covered the ground, prairie chickens sometimes used wind-swept locations near small yucca plants and clumps of little bluestem for daytime loafing on the northeast area.

Little opportunity was provided for studying roosting in snow since snow was lacking during much of the study period. However, on November 11, about 30 minutes after sunset, two chickens were flushed from roost forms in fresh snow about four inches deep. The forms, each situated on the south side of a clump of grass, were located in a thick stand of mixed grasses 230 yards from the edge of the nearest cornfield. Surrounding grasses provided thick cover to a height of 17 inches; a few stems reached three feet in height. Each form was well rounded, oval in shape, and large enough for only one bird. Another form, apparently used for only a few minutes before the occupant was flushed, showed that the bird after alighting had walked about four feet in loose snow before settling down to hollow out the form.

Monson (1934) reported that during the winter in North Dakota prairie chickens feed in cornfields and sleep in the deep snow on meadowlands. Bent (1932) wrote that prairie chickens often dig into deep snow drifts for roosting.

ACTIVITY AT BOOMING GROUND

Stoddard (1922) observed that in southern Wisconsin prairie chickens used knolls for cooing grounds. He also wrote of the activity on these grounds, mentioning the early morning arrival, the jumping, tail spreading, wing drooping, and fighting which accompanied the spring cooing.

A low ridge on the southwest area located between the roosting place and the cornfield was used on several mornings as a display ground and sunning place before the prairie chickens entered the field to feed. This ridge had a covering of short grass and is the usual spring booming ground, according to Charles Schamel.

On October 23 two males were observed at this location shortly after sunrise. They faced each other, at a

distance of one or two feet, and jumped towards each other with fluttering wings and feet extending forward while in mid-air. Upon alighting, one individual, with its neck tufts up and head lowered, chased the other about 20 feet. Both birds later walked towards the feeding place.

On November 23 a similar performance was observed. Much fluttering of wings and running about was noticed. Several males paraded with tails spread and neck tufts held up and forward. Much "talking", not unlike that of barnyard fowls, could be plainly heard from a distance of 200 yards. Two males, both with tails and neck tufts up, faced each other at close range for at least 15 minutes. They ducked, circled, and sparred but did not touch each other at any time.

On November 29, a clear, frosty, spring-like morning, the parading lasted about 40 minutes, after beginning at sunrise. Seven birds chased one another about as they crossed the open area towards the field. Another group of six males repeated this act a half-hour later. Two more males staged a mock battle. They faced each other and jumped upward and backward. At other times one jumped over the other, but at no time was actual contact evident. These observations of fall booming ground activity correspond closely with territorial disputes as described by Schwartz (1945).

Howard (1920), referring to birds in general, wrote that the process of establishing themselves on the breeding ground was gradual in males of non-migrants, the individuals oscillating between their winter habits of feeding and the spring disposition to seek the breeding ground. Late fall behaviour at the booming grounds is perhaps evidence of the same process in prairie chickens.

I did not hear the booming sound during the fall investigation. Charles Schamel reported booming on September 27, 1940. He also reported that the first booming noticed in 1941 occurred on February 10. Farmers who were interviewed mentioned April as the most important month for booming.

Hamerstrom (1939) noted some booming in October,—some booming grounds were not wholly abandoned all winter, some birds loafing there even when snow was on the ground. The same writer reported that in Wisconsin, March booming was sporadic. He recorded March 2, 1938, as the earliest observance of the complete performance. He observed earlier displays during thaws in February and believed booming to be regulated by the joint action of light and temperature.

HOME RANGE

With the exception of one flock mentioned earlier, prairie chickens on both study areas seemed to be definitely established on what may be termed a home range. A flock was never observed alighting more than three-fourths of a mile from the take-off point. On one occasion a flock made a circling flight of about two miles on the wing, after being flushed, but alighted only about one-half mile from the flushing point. When flushed, birds often circled or doubled back over the observer in order to reach a more central part of the local range.

On the northeast area at least one resident farmer living only one-half

mile beyond the periphery of the apparent local home range was surprised to learn that a large flock was wintering in the vicinity. It appears that if prairie chickens are not observed in the right spots they are not likely to be seen at all.

FLUSHING AND FLIGHT DISTANCES

Flushing usually occurred incidentally to activity in the field in gathering data on grasses. Purposeful disturbance was held to a minimum so that the birds might be studied under as nearly ordinary conditions as possible.

On the northeast area an average of 14.6 birds were flushed in 16 flushes. Data on 13 flushes show an average flushing distance of 53.4 yards. The three flushes at distances greater than 50 yards contained more birds than flocks flushed at shorter distances. Birds flushed from roosts during conditions of semi-darkness averaged 190 yards in flight distance. The flight distance of eight daytime flushes averaged 642 yards.

On the southwest area 27 different flushes put up an average of 5.3 birds. On 21 flushes for which data are available the flushing distance averaged 34 yards. Flushing distances varied from 10 to 130 yards. On only two of the 27 flushes was the flushing distance greater than 50 yards. It may be significant that both these instances occurred in sage brush cover used temporarily in section 9. A single bird flushed at 100 yards and a flock of 35 flushed at the same distance. The flock made an unusually long, circling flight following this disturbance. The long flushing distance and the following lengthy flight may indicate that prairie chickens are less secure in surroundings with which they are less familiar. Flight distances at the southwest area averaged 543 yards. Nelson (1939), observing southeastern Minnesota prairie chickens, found the birds were unusually timid and usually flushed over 100 yards, travelling beyond human vision before alighting.

For each area, and for the combined areas, flushing distances increased as the season advanced. Eleven October flushes averaged 23.2 yards; ten November flushes averaged 43.5 yards; thirteen December flushes averaged 57.6 yards. Cornfield flushing distances averaged 31.6 yards compared to 41.4 yards for all flushes.

Persons interested in prairie chickens have sometimes wondered why these birds seldom occupy small areas even though the grassy cover is excellent. The long normal flight distance may help to explain this; it seems reasonable that a flock might prefer an area of such extent that several flights, following consecutive flushes, could be made without leaving the preferred kind of cover. This would not be possible on small areas.

DISTURBANCES BY HAWKS

Behavior when hawks approached on wing indicated that prairie chickens fear the attacks of hawks. Hawks caused prairie chickens to flush on 17 observed occasions. In only four instances did hawks actually pursue the flushing birds. Hawks attacking or pursuing prairie chickens were identified as prairie falcons (*Falco mexicanus*). No actual capture of prairie chickens by hawks was seen.

Prairie chickens often flushed, par-

ticularly from cornfields, when American rough-legged hawks (*Buteo lagopus s. johannis*) or marsh hawks (*Circus hudsonius*) flew overhead. These hawks always seemed to ignore the chickens.

USE OF TREES

Six prairie chickens were observed in cottonwood trees (*Populus deltoides*) in December when about 10 inches of fresh snow covered the ground. Whether or not buds were taken on this occasion could not be determined. This marked the only time during the investigation that chickens were seen in trees. Bent (1932) reported that although prairie chickens sometimes alighted in trees their roosting was on the ground.

USE OF WATER

The overflow from stock watering tanks on the Schamel farm formed a waterhole protected by willows (*Salix sp.*). Mr. Schamel stated that prairie chickens drank from the waterhole and from the tanks during dry weather. Mr. Lou Hiatt (in conversation) said that chickens obtained water at stock tanks in a pasture one mile south of Schamel's.

OTHER BIRDS ON THE AREAS

Besides prairie chickens, and the hawks already mentioned, the ring-necked pheasant (*Phasianus colchicus torquatus*) and the western meadowlark (*Sturnella neglecta*) were the most common birds occupying the study areas. A few pheasants fed in the same field near the prairie chickens at almost every observed feeding period. The roosting and loafing cover used most by the pheasants consisted of weedy small grain stubble, weedy uncut sweet clover (*Melilotus sp.*), and a weedy uncut mixture of sorghums and sweet clover. Such cover was used very little by prairie chickens as daytime loafing or escape cover and never for night roosting cover.

Interviews with farmers revealed a rather common belief that the introduction and increase of pheasants had been responsible for the decline in prairie chicken population, but most of them lacked evidence to substantiate this belief. Because of such beliefs particular attention was given to field observation of pheasants in prairie chicken areas during the study. No conflict of any kind was seen. Four persons stated that they had witnessed attacks upon prairie chickens by male pheasants. In two of these cases pheasants were reported to have killed young prairie chickens.

Eastern crows (*Corvus brachyrhynchos*) were seen several times, usually flying high and going towards yards where cattle were being fed. American magpies (*Pica pica hudsonia*) were seen several times, usually around carrion in pastures, or near trees.

Several species of waterfowl used waterholes in the Schamel pasture regularly during the fall migration. The species seen included common mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), shoveller (*Spatula clypeata*), and green-winged teal (*Anas carolinense*).

Prairie sharp-tailed grouse (*Pedioecetes phasianellus campestris*), occasionally reported in Chase County, were not seen during this study. If present, this species is undoubtedly rare. A few western burrowing owls (*Speotyto cunicularia hypugaea*) were seen.

MAMMALS ON THE AREAS

Coyotes (*Canis nebracensis nebracensis*) were seen frequently on both study areas. In late afternoon in October a coyote was observed passing through a cornfield in which prairie chickens were feeding. The chickens did not flush. The coyote continued through the field and, upon emerging from the field near the farm buildings, captured a domestic chicken. On another occasion a coyote was photographed while stalking a great plains jack rabbit (*Lepus californicus melanotis*). The great plains jack rabbit, locally known as the black-tailed jack rabbit, was common in both areas. Walking trips through grasslands invariably flushed one or more of these large rabbits.

A farm dog on the southwest area frequently used the base of a sorghum shock as a bedding place. Prairie chickens sometimes fed within 30 yards of this dog.

Cattle, running through grass in which prairie chickens were resting, did not cause the birds to flush. Hogs often fed in the same field with the birds. House cats in passing through the same field to reach hunting grounds beyond in small grain stubble caused no disturbance.

SUMMARY

Prairie chickens formerly occupied practically the whole state of Nebraska, but their range has been restricted through reduction of habitat since 1920.

Fall studies on two Chase County areas in 1940 covered local ranges of two flocks, each numbering over 50 prairie chickens by December. Flock sizes increased during the fall. Prairie chickens on both areas seemed to have definite home ranges covering about 2,000 acres or more.

Cornfields were used for 37 observed feeding periods, and sorghum shocks for 21 periods. Rye stubble and Sudan grass shocks were used four times each. Sorghum shocks were used more when deep snow made cornfield feeding unattractive.

Flocks usually moved into feeding places on wing. Feeding periods lasted about 82 minutes. Morning feeding began near sunrise. Evening flights from feeding areas to night roosting cover were made at an average interval of nearly 25 minutes after sunset.

Dense cover of native grasses was the preferred roosting cover; sagebrush was used only temporarily. Typical roosting cover had numerous tall stems, dense cover from one to two feet above the ground, and a dense understory covering the ground to a depth of eight inches or more. Heavily grazed areas lacked good ground cover and were avoided by prairie chickens.

The distance from feeding places to night roosting places varied from one-eighth to three-fourths of a mile.

Considerable early morning displaying on a booming ground was noted on several mornings in October and November.

Flushing distances increased during the fall, averaging about 23 yards in October, 43 yards in November, and 58 yards in December. Flight distances averaged 642 yards and 543 yards for the two areas.

Prairie chickens often flushed when approached by hawks; American rough-legged hawks and marsh hawks disregarded the chickens but prairie falcons on several occasions pursued them.

Other wildlife on the study areas included western meadowlarks, pheasants, crows, magpies, four species of waterfowl, burrowing owls, coyotes, and jackrabbits.

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FACTORS INFLUENCING THE DISTRIBUTION AND ABUNDANCE OF THE WILD TURKEY IN WEST VIRGINIA

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Conservation Commission of West Virginia *

A scientific inquiry into the status of the wild turkey, *Meleagris gallopavo*, in West Virginia was begun in 1944. The first wild turkey census was completed the following year. A wild turkey investigation project was begun in 1946 and completed in 1947. Fred A. Glover, in charge of this project, classified the various types of turkey range, conducted an analysis of plant cover types on sample study areas and presented a general management plan for increasing turkey numbers in the state. As a follow-up on the recommendations of Glover, a development project, entitled Wild Turkey Restoration was initiated in July, 1947. The work of this project has been confined to state-owned parks, forests, and game refuges. Wild turkey habitat improvement has also been conducted on a rather large scale in West Virginia on the Monongahela National Forest. These projects, including a recent turkey census, were made possible through Federal Aid funds.

Although absolute accuracy is not claimed in a survey of this type, its periodic application has a practical value to the game administrator in setting seasons and bag limits, restocking of potential range, increasing the present ranges and populations, determining the effect of hunting pressure and in making an evaluation of the present day management techniques.

As far as is known, Missouri and West Virginia are the only two states that have rechecked the distribution and abundance of their turkey population over a period of years.

In order to keep track of wild turkey population trends, it is planned to conduct a census every five years. The 1949-50 census has lately been completed and the results will now be summarized.

The Turkey Census

The method outlined by Mosby and Handley (1943) was the primary procedure used on the survey. Early in July 1949 the 448 successful turkey hunters of the 1948 season were sent questionnaire forms and asked to report the number and location of turkeys seen during the open season. Approximately 70 per cent of the forms were returned. A similar procedure was used in the 1949 season and answers were received from 61 per cent. During the field work all conservation officers, refuge managers, forest custodians and U. S. Forest Service Rangers were contacted in obtaining information on turkey flock locations and numbers. Following this part of the survey local residents were

* A contribution from Pittman-Robertson Wildlife Restoration Projects 26-R and 19-D, Conservation Commission of West Virginia, Division of Game Management. Acknowledgment is given to Mr. George Breiding who assisted in the survey and Mr. Herbert C. Dahl for assisting in compiling the data.

contacted in each county. In many cases information received from this source was merely a cross check on information already gathered. In all cases when a flock was cross-checked the lowest number or the number of turkeys seen on the most recent date was used. Single sight records were not recorded in the final tabulation. Thus the final result is a very conservative estimate of West Virginia's turkey population.

The 1949-50 census reveals a total of 6,851 turkeys and shows a 14 per cent increase over the 1944-45 figure of 6,004 birds. The number of flocks increased 36 per cent from 508 to 692 during the same five year period. Wild turkey flocks were found in 26 counties as compared with only 21 counties in the 1944-45 survey.

All of the counties with apparently newly occupied turkey range were listed by Glover and Bailey (1947) as "potential range by restocking and management."

The two-mile cruising radius per flock suggested by Mosby and Handley (1943) was used during this survey in determining the "occupied wild turkey range." This is thought to be a conservative estimate of the cruising radius, especially in mountainous range.

The counties in which turkey flocks have been found contain 14,730 square miles of which 72 per cent (10,640 square miles) is in forest. Based on these figures, it was estimated that 5,414 square miles (36.7%) of the counties having turkeys were occupied, as compared with Glover's estimated 4,726 square miles in 1944-45. This is a 14.5 per cent increase in occupied territory. Based on forested land alone, 4,529 square miles, or 42.4 per cent, of the forest were estimated to be occupied range in the 1949-50 survey.

THE BASIC HABITAT

There are essentially three basic turkey areas in West Virginia, the Eastern Panhandle, the Mid-eastern and Southeastern West Virginia. They contain 95 per cent of the total turkey population.

In the Eastern Panhandle section the primary forest types are red oak, hard pine-oak, white oak and chestnut oak. The red oak type contains the most turkeys. In this area there was an increase of 33 per cent in turkey numbers.

In the Mid-eastern section the primary forest types are northern hardwoods, red oak and white oak. In this section northern hardwoods contain the most turkeys. There was only a 3.7 per cent increase in the turkey population in this section.

In the Southeastern section red oak and northern hardwoods are the primary forest types. The former contains the most turkeys. The increase in turkey numbers in this section was 8.9 per cent. Two counties in this section, however, had a decrease of 33 per cent and 50 per cent, respectively, in their turkey populations. These two counties are located in the western part of the section where lumbering, strip mining and general human activity have become prevalent.

CARRYING CAPACITY OF THE WEST VIRGINIA RANGE

Although the precise carrying capacity of the various forest types is unknown, it seems most logical that in

some mountainous areas turkey numbers, for years, have been as high as the land is capable of supporting. For example, the winter population on the Nathaniel Mountain Game Refuge in Hampshire County and on the Kumbrabow State Forest in Randolph County, has remained nearly stationary for the past five years.

The highest concentration of turkeys known in the state occurs on a 53.4 square mile area in Morgan County, which has a winter population of 174 birds. This is equal to .27 square miles or 171 acres per turkey. Another area in Randolph County, totaling 81 square miles, has one turkey per 208 acres of forested land. A third area of 110 square miles in Hampshire County has one turkey per 304 acres of forested land. Stoddard (1935) stated that the better turkey range in Georgia supported about one turkey per 25 acres. It is believed that in West Virginia, fall turkey populations do not exceed one bird per 125 acres on the better range.

EFFECT OF SOIL

Dalke *et al.* (1946) in Missouri found a distinct correlation between turkey numbers and soil types. In West Virginia, soil types have been determined with reference to each precise flock location and no relationship between soil type and turkey numbers was indicated. The principal soils occurring on occupied turkey range belong to what is classified as Rough Stony Land and to the DeKalb series. Both of these soil types are relatively poor and shallow, thus the turkey is today found principally on the sterile and forbidding soils of the mountains only because man has occupied the more fertile lowlands.

EFFECT OF FOREST TYPE

In determining the forest type in which the turkeys were found, a two mile radius was drawn around each flock location. The forest type composing the greatest acreage within the two mile radius was assumed to be the influencing type.

For the turkey range as a whole, the following facts were evident (Table 1):

1. Red and white oak types and northern hardwood type were the three forest associations in which the greatest number of turkeys was found.
2. The greatest densities, however, were in hardwood-spruce-fir, northern hardwoods and hard pine-oak types.
3. The oak types comprise three times as much acreage as northern hardwoods but contain less than twice the number of turkeys.
4. Forest types including cove hardwoods, pitch-shortleaf and Virginia pine; hardwoods-spruce-fir, spruce-fir hardwoods and aspen-pin cherry types in total comprise 30 per cent more acreage than northern hardwoods yet the latter holds over 75 per cent more birds.

All of these facts would seem to indicate that northern hardwoods are more attractive to turkeys on the basis of type alone. However, when an area by area study is made it appears more likely that elevation, topography, accessibility and general location of the forest types are more important in regard to the capacity of the area to

TABLE 1.—INCIDENCE OF TURKEY NUMBERS ON FOREST TYPES IN OCCUPIED COUNTIES

FOREST TYPE	Total Acreage in Sq. Miles	Per Cent of Total Acreage	Number Turkeys	Per Cent of Total Turkeys in Each Type	Sq. Miles of Each Type Per Turkey [2]
Red Oak	4,129.0	37.5	2,298	33.5	1.4
Northern Hardwoods	2,170.0	19.7	2,209	32.3	1.0
Hard Pine-Oak	684.0	6.2	856	12.4	0.8
White Oak	[1]	0.0	591	8.6	0.0
Chestnut Oak	1,199.0	10.9	292	4.2	4.1
Cove Hardwoods	2,012.0	18.3	243	3.5	8.2
Pitch, Short Leaf, Virginia Pine	188.0	1.7	181	2.6	1.0
Hdwd. Spruce Fir	73.0	.7	99	1.7	0.7
Spruce-Fir-Hdwds	95.0	.9	55	0.8	1.7
Aspen-Gray Birch-Pin Cherry	[3]	0.0	27	0.4	0.0
Other Types [4]	453.0	4.1	0	0.0	0.0
Total	11,003.0	100.0	6,851	100.0	1.6

[1] Red and White types are combined.
[2] Occupied and unoccupied forests.
[3] No data on acreage available.
[4] The term 'Other Types' includes the forest types that do not contain turkeys in any part of the State. The types are spruce, tamarack-cedar-spruce, and bottomland hardwoods.

support turkeys than are the forest types themselves. For example, in the Eastern Panhandle section the red oak and white oak types occupy ten times more acreage than do the northern hardwoods type but they also support 28 times as many turkeys. In the Mid-eastern section the reverse trend is found. In the Eastern Panhandle section the oak types are usually found in the more inaccessible areas while in the Mid-eastern section northern hardwoods occupy these areas.

The only conclusion that can be drawn on the basis of available data is that turkeys have been forced into areas relatively inaccessible because of elevation or topography, or into areas comparatively free of human disturbances.

EFFECT OF HUNTING

It is significant that in the counties closed to turkey hunting because of low populations very few flocks were composed of more than 15 birds and at least 50 per cent of the flocks consisted of five birds or less. Only one county that was completely open to hunting has over 30 per cent of its flock composed of five birds or less. The turkey population in this county is believed to be decreasing and the county may eventually have to be closed to hunting. Thus, an indication of a decreasing population in a county is probably shown by an increase in the number of flocks containing five birds or less. Although flock size is often influenced by weather conditions, there was no significant difference in the weather in counties open to hunting and those closed to turkey hunters during the period of the survey.

There is often much comment by the sportsmen of West Virginia regarding the legal kill. Many believe that the wild turkey is being overhunted. In many sections of the state it is hearsay that only 50 per cent of the hunters

report their kill. However, the recorded turkey kill in 1944 was only six per cent of the total population. The 1949 recorded kill was 11.6 per cent of the population in the counties open to hunting. Assuming that only 50 per cent of the kill was reported the recorded kill may be doubled. This gives a kill of 23.2 per cent of the 1949-50 population. Such a kill probably would be within the bounds of safety. A concerted effort to determine the unreported kill during the 1949 season resulted in the knowledge that at least 16.6 per cent of the hunters did not report their kill. Although this is considered a low estimate of the unreported kills, it is not believed that the number failing to report was as high as 50 per cent. The recent survey indicates that the turkeys are holding their own or increasing in most of West Virginia where the habitat is suitable. Where they are decreasing the primary causes for the decrease are other than legal hunting.

An interesting point in regard to the annual reported turkey kill by hunters is the evidence of a three year cycle of such kills (Table 2). For example, the reported kills for the years 1940, 1943, 1946, and 1949 were all in excess of 500 turkeys. In the "in-between" years, less than 500 turkeys were reported killed with all years save two showing less than 400 killed. Since the difference between the trough and crest of the cycle is frequently as great as 75 per cent from one year to another, it must be assumed that the reported take is greatly influenced by hunting conditions or by factors other than the size of the turkey population.

TABLE 2.—REPORTED WILD TURKEY KILL IN WEST VIRGINIA—1940–1950

Area Open to Turkey Hunting			
YEAR	Counties	Forested Land Sq. Miles	Reported Kill*
1940	13	5945.8	**514**
1941	13	6039.3	470
1942	14	6106.0	391
1943	15	6444.7	**618**
1944	15	6444.7	365
1945	13	6340.2	350
1946	12	5790.1	**559**
1947	12	5790.1	227
1948	12	5790.1	448
1949	12	5790.1	**749****
1950	12	5790.1	420

* The three year high in the kill is in bold figures.

** Only 625 of these were reported by hunters. The remaining 124 were obtained in a special effort to determine the unreported kill.

EFFECT OF WEATHER

Climatological records for the years 1940-49 were reviewed in an effort to determine the possible effects of snowfall during the winter and precipitation and minimum temperatures during the brooding period (May 15 to June 15) upon the turkey population as reflected in the reported annual kill.

The kill appears to be somewhat correlated to the extent of freezing temperatures occurring during May. Further data are needed to prove the precise effects of freezing temperatures during the egg-laying or brooding period upon the reported kill.

Excessive snowfall may also influence the legal kill. For example, during the months of January, February and March, 1947 the average snowfall for all forest types was approximately 100 per cent greater than for the preceding and succeeding years. Continuous snowcover existed for a period of about two months with a total maximum depth of 50 inches in the northern hardwoods

forest. During this period of severe weather, several turkeys, all juveniles, were found dead of starvation. The reported kill of 227 birds the following fall was the lowest in the ten year period. However, the low fitted into its regular place in the three-year cycle, previously mentioned. The recent population increase of the turkey in most sections of the state may be, to a considerable extent, the result of the relative snowlessness of the winters of 1948-49, and 1949-50.

The turkey is an extremely hardy bird and the adults rarely, if ever, perish from cold alone. January and March of 1940 were considerably below average in temperature, with the former month being the coldest on record. During the following hunting season 514 turkey kills were reported, a "high" in the three-year cycle.

An attempt was also made to correlate the legal kill with precipitation during May and June. Strangely, the years showing the highest rainfall had higher kills.

Since periods of high precipitation are frequently accompanied by higher-than-normal temperatures, it logically follows that temperature is a more important factor than precipitation. In connection with this, Gerstell (1936) in Pennsylvania found that high summer precipitation and high hunting take of bobwhite were closely correlated.

EFFECTS OF THE AVAILABLE FOOD SUPPLY

In an attempt to further correlate the three year "high" in the cycle of turkey kills, the relative mast abundance of each season was compared with the reported kill and the minimum temperatures during May of that year. Mosby and Handley (1943) referred to acorns as the turkey's "staff of life" and various other authorities, particularly in the Southwest, have shown that turkey numbers are frequently closely related to the available acorn supply. Results of studies in West Virginia indicate that the correlation of the reported turkey kill to the mast supply exists in this state, but such relation is coincidental. More correctly, the mast supply and the turkey kill are each related to minimum temperatures occurring during May.

While no attempt is here being made to minimize the importance of mast (fruits of the oaks and the beech) in the diet of the turkey, it is the belief of the writers that in West Virginia other foods such as sassafras, black gum, wild cherry, dogwood, greenbrier, deciduous holly, wild grape, pipe vine (*Aristolochia tomentosa*), black locust, grass, insects,* underground tubers, and dozens of others are of sufficient abundance and distribution as to preclude the likelihood of turkeys starving except during periods of deep and continuous snow cover. Under severe snow conditions flocks can subsist for two to six weeks on an emergency diet of dried blackberries, ferns, mosses, and buds.

The effect of a period of starvation, or emergency ration on the breeding activity or egg-laying potential of the surviving turkeys is an unknown factor as far as the writers can determine.

EFFECT OF HUMAN ACTIVITIES

Mining and industry with their consequent human activity spell the doom

* Of secondary importance only in winter.

of the turkey in the area being exploited. Climatologically and ecologically, our mining and industrial centers often would provide the best in turkey habitat were they not heavily settled with humans. The degree of the future development of mining and the expansion of industry will determine to no small extent the future of this game bird in the state.

EFFECT OF PREDATION

For the purpose of determining the possible effect of the fox on turkey numbers in West Virginia, Glover (1947) analyzed 473 fox scats collected in turkey range. Results of his study compared with similar studies in other states in that white-footed mice (*Peromyscus* spp.), meadow mice (*Microtus* spp.), and cottontail rabbit (*Sylvilagus* spp.) were the three most important items eaten. Wild turkey remains were identified in nine scats collected in the months of January and March. There was good field evidence indicating that these nine occurrences were the result of only two kills. At least one of the turkeys was in a semi-starved condition when it fell victim to a fox.

In West Virginia, as in other states, there are no indications that predation by foxes, bobcats, eagles, or the like is a determining factor in wild turkey numbers.

EFFECT OF MANAGEMENT PRACTICES

The Monongahela National Forest, located in the eastern part of West Virginia, is an area of almost 806,000 acres. It encompasses about 28 per cent of the occupied turkey habitat of the state, most of which is in the northern hardwoods forest type. This area has a population of approximately 1,900 turkeys, roughly 28 per cent of the total population.

In 1946 the Conservation Commission of West Virginia and the U. S. Forest Service entered into a cooperative agreement concerning wildlife management on the Monongahela National Forest. Under this arrangement eleven wildlife management units, totaling 303,600 acres, or 37.6 per cent of the forest, were established. Each unit has a resident manager and a part-time labor force. A total of 544 clearings have been created, seeded and properly fertilized. Many other management methods have been undertaken. In spite of all management measures and winter feeding, turkeys found within the areas did not exceed in number those without the management areas. On range where turkey management has been undertaken the total per cent of increase in the number of turkey flocks was 17.6 per cent. Since the state-wide increase was 36 per cent, it is obvious that a similar increase occurred outside the managed areas over a much larger proportion of the turkey habitat. It is quite possible, however, that these managed areas draw more hunting pressure to the surrounding areas and are actually producing more than is indicated by the survey.

The argument might be forthcoming that these areas also influence some acreage around them; however, when the additional acreage is considered the picture does not change materially. Also, the six state-owned areas, totaling 53,830 acres and managed under the Wild Turkey Restoration Project, have shown no substantial increase in turkey numbers within the last five years.

Despite these observations, it is believed that the turkey population might seriously decline if these management areas were abolished. Further, it should be considered that most of the developments on these areas have been established for too brief a time for their effects to be accurately measured.

In reviewing the various factors influencing the wild turkey, it is obvious that the potential increase expected, based on the total population that existed in 1945, was not forthcoming. Apparently, the increase is limited by factors other than those discussed in this paper.

There is little known in regard to the per cent of hatched poults that reach the hunting season. Although broods of seven birds or more are often seen in August, the number of hens deserting their nests or having no young for other reasons, is unknown. It is believed that the greatest loss of turkeys occurs between the hatching period and the hunting season. More research is needed to determine the critical period of the turkey in West Virginia.

FUTURE OF THE TURKEY

In regard to the future of the turkey in West Virginia, it appears likely that no serious decline will occur within the next few decades unless an unexpected expansion of timber cutting and industry growth takes place in our more extensive forested areas. It is to be expected that local contractions and expansions of occupied range will occur from time to time. Although the turkey's outlook is not altogether bright, there are good indications that the unexcelled sport of turkey hunting may endure for some time to come.

SUMMARY

1. The 1949-50 census revealed a total of 6,851 turkeys and, when compared with the 1944-45 census, showed a 14 per cent increase during the five-year period.
2. There are three basic turkey areas in West Virginia with several forest types found in each. The increase in turkeys varied from 3.7 to 33 per cent on these areas during the five-year period.
3. The highest winter population in West Virginia occurred on an 81 square mile area in Morgan County which had one turkey per 171 acres of forested land. It is believed fall populations probably never exceed one turkey per 125 acres in West Virginia.
4. It appears that elevation, topography, accessibility and general location of the soil and forest types are more influential in determining where turkeys are found than are the types themselves.
5. The legal kill and the winter kill are not of major importance in reducing the turkey population in West Virginia. The reported kill for 1944 was six per cent of the population; in 1949 it was 11.6 per cent.
6. The turkey kill and mast conditions correlate with minimum temperatures occurring during May. The greater the extent of below normal temperatures for that month, the poorer the crop of mast and the lower the reported turkey kill of the same year.
7. In spite of management measures and winter feeding, turkeys found

within the managed areas did not exceed in number those outside the areas. These managed areas probably draw additional hunting pressure, accounting for the apparent lack of increase.

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MONTHLY DISTRIBUTIONS OF MALLARD HUNTING MORTALITY[1]

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For several decades, the management of waterfowl populations has been importantly concerned with legal restrictions of the harvest. Annual evaluation of the effects of these regulations is now carried out in an intensive manner by many agencies along two separate lines: hunter-success studies (ducks bagged per hunter per day, etc.) and band-recovery-rate analyses (percentage of birds reported shot after banding). Both of these areas of inquiry involve statistics that vary annually and can be used to appraise the effectiveness of restrictive legislation. The well-known variables in these data are, of course, the weather and the timing of major migratory flights to the south. Dating of these movements represents a third type of inquiry that poses particularly difficult field problems for the waterfowl biologist. Currently unpublished work of the Mississippi Flyway Waterfowl Biologists' Committee indicates that major movements of geese (*Branta canadensis, Chen caerulescens*) and mallards (*Anas platyrhynchos*) are being accurately dated as they progress down the continent. Lesser migratory peaks are being observed locally, but their continental significance still remains obscure. Even when the number of waterfowl remains approximately constant at some point along their migration route, we are often unable to determine if many birds are arriving daily and how many are similarly departing. As a result, our annual estimate

[1] A joint contribution of the U.S. Fish and Wildlife Service and the University of Wisconsin, made possible by a fellowship of the John Simon Guggenheim Memorial Foundation.

of how regulations and the weather separately affect the waterfowl harvest is still very much a subjective one for major regions as large as a flyway.

In this paper, I wish to expand this third field of inquiry by examining the monthly distribution of hunting mortality reported for banded mallards. If these banded birds show important annual variations as to the months in which they were shot, we will advance one step toward obtaining objective criteria to measure the effect of weather conditions on the total kill in a given region.

Materials and Methods. The banding records used here are those filed by the U.S. Fish and Wildlife Service at its Patuxent Research Refuge, Laurel, Maryland. I have reason to believe that the age determinations of the banded birds cited below are accurate, that hand-reared birds were excluded from the samples, and that minor errors (some involving the month) mar 4.6 per cent of the recovery dates listed. In all cases, mortality reports were omitted if a bird was banded during the hunting season and shot before the end of that season. Juvenile or immature birds were those banded before September 1; the adults were generally banded in some hunting season previous to the one in which they were shot. Wherever possible, the percentage frequencies have been carried out to one decimal place, not to imply that this last digit is a significant one but rather to permit a better comprehension of the sampling limits that govern these distributions. The mortality recorded by the banding system imperfectly reflects the take by illiterate hunters such as the Indians in Canada; their reports are essentially excluded from the present study. This imperfection is also believed to be present to a lesser extent among records involving American hunters, since only a fraction of the recovered bands are ordinarily reported. Unwillingness to report duck bands possibly follows some (as yet undetermined) geographic gradient. Under ordinary circumstances, it should not importantly vary from one year to the next.

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GENERAL MONTHLY PATTERNS

Bellrose and Chase (1950) have reported that, of the mallards banded at Lake Chautauqua, Illinois, very few were killed in September, more in October, and most in November, with the kill declining through December. In Table 1, this generalization is tested for adults banded in other parts of the continent: 1245 by A. J. Butler in British Columbia, 442 by Ducks Unlimited (Canada) and other banders in the prairie provinces, 604 by F. H. Rose in western Montana, and 592 mostly by Merrill Hammond and C. J. Henry in North Dakota. In general,

TABLE 1.—OVERALL MONTHLY FREQUENCIES OF HUNTING MORTALITY IN ADULT MALLARDS

When Recorded Shot		Sept.	Oct.	Nov.	Dec.	Jan.	Total
Where Banded	Size of Sample	Per Cent of Each Sample					
Alberta	150	11.3	29.3*	36.7	21.3	1.3*	99.9
Saskatchewan	209	6.7	17.2	49.3	18.2	8.6	100.0
Manitoba	83	8.4	29.0	35.0	25.3	2.4	100.1
Subtotal	442	8.6	23.5	42.3	20.6	5.0	100.0
British Col.	1245	5.7*	18.9	46.6	23.7	5.1	100.0
Montana	604	11.4*	17.4	39.0*	21.7	10.6*	100.1
No. Dakota	592	5.4	23.5	45.8	22.5	3.9	100.1
Total	2883	7.3	20.3	44.2	22.5	5.8	100.1

* Significantly differs from value given for total at 95% level of probability

the monthly frequencies are of the same order as those reported for Illinois (*ibid.*). The Montana sample exhibited the greatest divergence in this series. Because this Montana set of data originates from banding operations covering a relatively few years (the others often representing a 10- to 20-year period), one is tempted to infer that the distributional frequencies shown here are typical of conditions in the aggregate and do not necessarily hold for any given year. It is of some interest that the September-October kill totalled 32.1 per cent for birds banded in the prairie provinces, 28.9 per cent for those banded in North Dakota, and 28.8 per cent for those banded in Montana.

Samples of mallards shot in their first year of life are broken down in Table 2 along somewhat similar lines. The span of years covered here runs 1925-46 for the Canadian-banded birds and 1925-45 for the others. Under Canada, Alberta, Saskatchewan, Manitoba, and British Columbia are represented in that order, the main banders being personnel employed by Ducks Unlimited (Canada). Among the birds tabulated for the northern states are 15 from Montana, 21 from North Dakota, 17 from South Dakota, 67 from Minnesota, 11 from Wisconsin, and 36 from Michigan; the bulk of these U.S.-banded birds were trapped by refuge personnel of the U.S. Fish and Wildlife Service. Under "other states" in this table are 4

TABLE 2.—OVERALL MONTHLY FREQUENCIES OF HUNTING MORTALITY IN IMMATURE MALLARDS

When Recorded Shot		Sept.	Oct.	Nov.	Dec.	Jan.	Total
Where Banded	Size of Sample	Per Cent of Each Sample					
Canada	302	13.9	25.2*	38.4	18.9	3.6	100.0
No. States	167	9.0	34.7	37.7	17.4	1.2	100.0
Other States	141	7.9	49.6*	18.4*	21.3	2.8	100.0
Total	610	11.1	33.4	33.6	19.0	2.8	99.9

* Differs significantly from percentage in total at 95% level of probability

birds banded in Oregon, 23 from California, 71 from Utah, 2 from Nebraska, and 41 from northeastern Illinois. The 610 young in this table were all the wild-reared juveniles that the banding files of the Fish and Wildlife Service contained as of July, 1947; hand-reared birds and birds of doubtful origin were rigorously excluded.

Considering the gradient from north to south, one notices in Table 2 that the September frequencies decrease in an interesting but not statistically significant fashion, while the October frequencies display a striking increase from 25 to 50 per cent. This extremely high October kill in the more southerly of these three zones is due mostly to bandings in California and Utah where, out of 96 birds reported shot in their first year of life, 60 per cent were shot in October. The relatively high October hunting mortality for all immature mallards is quite in contrast to that of adult birds and undoubtedly reflects the juveniles' rather temporary lack of wariness to the gun. It seems to me also probable that these early-season phenomena reflect geographic variations in the opening dates of hunting seasons. No September mortality was reported for 128 birds banded in Oregon, California, Utah, South Dakota, and Wisconsin.

From these data, I conclude (1) that a recognizable pattern of monthly hunting mortality exists for banded mallards; (2) that the pattern differs importantly between birds shot in their first year of life and those shot as adults; and (3) that, at least for juveniles, the pattern exhibits a logical geographic gradient according to the latitude in which the birds were banded.

ANNUAL VARIATION IN MONTHLY PATTERNS

That the annual flight southward of waterfowl varies in date according to the weather is well known to both biologists and sportsmen. These variations undoubtedly affect the monthly distribution of hunting mortality in the mallard, and some presumed examples from the work of A. J. Butler in British Columbia are given in Fig. 1.

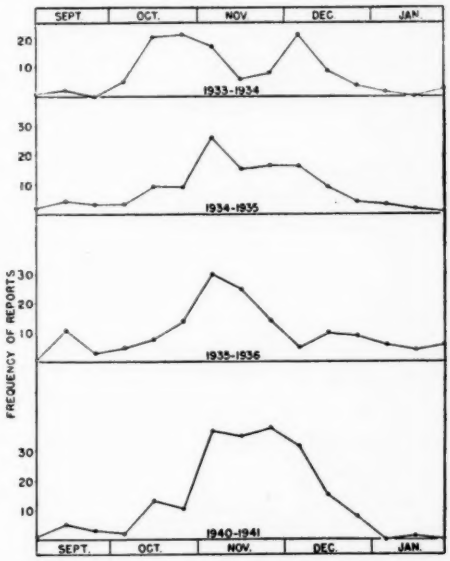

FIG. 1. Annual variation in the distribution of 721 hunters' reports of adult mallards banded in British Columbia by A. J. Butler. In these four years, hunting seasons in the state of Washington varied as follows: Oct. 16-Dec. 15, 1933; Oct. 19-Dec. 23, 1934, with "rest days"; Oct. 21-Nov. 19, 1935; and Oct. 16-Dec. 14, 1940. Hunting seasons in the four zones of British Columbia were usually 2.5 months stretching in the aggregate from Sept. 1 to Jan. 29 or 31.

Another illustration of how adult kill varies annually is given in Table 3 for a Mississippi Valley group banded in Saskatchewan, Manitoba, Minnesota, Wisconsin, Illinois (exclusive of Lake

TABLE 3.—MONTHLY VARIATION IN REPORTED HUNTING MORTALITY OF BANDED ADULT MISSISSIPPI VALLEY MALLARDS

Hunting Season Size of Sample	'39–40 366	'40–41 465	'41–42 448	'42–43 347	'43–44 300	'44–45 423	'45–46 352	'46–47 332	Total 3033
Month Recorded	Per Cent Recorded								
September	5.5	2.4*	4.2	6.9	8.7	8.3	9.9*	4.5	6.1
October	45.4*	22.8*	30.1	26.2	33.0	25.8*	24.7*	43.1*	30.9
November	30.9	48.2*	42.4*	35.7	34.0	30.7*	33.5	27.4*	36.0
December	16.9*	24.7	22.1	25.6	17.7	24.3	23.3	17.2*	21.8
January	1.4*	1.9*	1.1*	5.5	6.7	10.9*	8.5*	7.8*	5.3
Sept.–Oct. only	50.9*	25.2*	34.3	33.1	41.7	34.1	34.6	48.6*	37.0

* Differs from total at 95 per cent level of probability

Chautauqua), Missouri, Arkansas, and Louisiana. The bulk of the banding work here was done by L. H. Barkhausen, H. R. Buettner, David Damon, C. J. Goetz, John Jedlicka, E. A. McIlhenny, M. K. Nelson, L. A. Parker, and personnel of Ducks Unlimited (Canada).

If the 8-year total in this table is taken as our best estimate of average conditions, it would seem that in only two seasons (1942-43 and 1943-44) out of 8 was there a "normal" distribution of the kill. Significantly high October kills occurred in 1939-40 and 1946-47; low October kills occurred in 1940-41, 1944-45, and 1945-46. While some changes in hunting regulations undoubtedly affected these frequency distributions (especially in the series for January), it is highly unlikely that these would have changed the September-October kill from 51 per cent in one year to 25 per cent in the next.

Some correlation of these data with early and late autumnal flights can be evaluated by studying Bellrose's (1944) observations on the density of mallards present each fall in the Illinois River Valley from 1939 to 1942 (Fig. 2). While it is difficult to interpret these census polygons as indices of what happened each year throughout the Mississippi Valley, the high October kill in 1939 seems to have coincided with a fall flight that reached a high peak in Illinois during October and maintained a plateau there in numbers for the next 6 weeks. Low October kills in the next 3 years similarly coincide with peak numbers in Illinois that were not

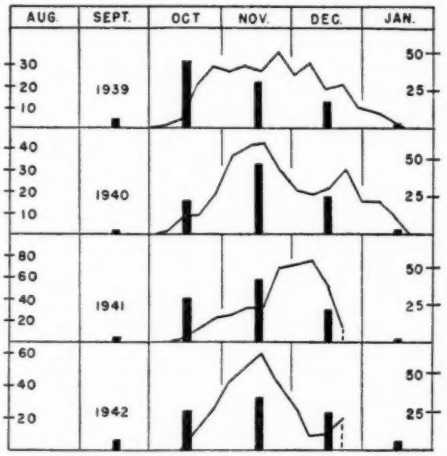

FIG. 2. Polygons indicating the relative density of mallards in the Illinois River Valley, reported by Bellrose (1944), and histograms showing the monthly distribution of hunting mortality of 1626 Mississippi Valley adult mallards taken from Table 4. Ordinate values on the left: number of birds per acre of water surface in the Illinois River Valley; on the right: monthly percentage of the hunting-season kill for all birds, Canada to the Gulf Coast.

observed until later in the season. What seems to have been a late flight southward in 1941 down the Illinois River is not reflected in the kill statistics here examined.

From these data, two tentative conclusions may be drawn at this time: (1) that the mortality of banded mallards follows a monthly pattern fairly consistent with field observations of peak flights and (2) that marked annual variations in these patterns may well aid waterfowl management in determining how weather modified the harvest expected under a given set of hunting regulations.

DISCUSSION

At the present time almost nothing is known regarding the reliability of banded birds as randomized samples of regional waterfowl populations. This greatly limits the inferences that can be drawn from the crude collections of data assembled here. We need to know not only how seasonal recovery rates vary from one banding station to another, but also what variations (if any) exist between stations in such matters as the monthly and geographical distribution of hunting mortality, annual fluctuations in mortality rates, and seasonal phenology of migratory flights.

Among the peculiar results of this investigation may be mentioned two sets of monthly frequencies obtained for adults from the prairie provinces, British Columbia, Montana and North Dakota examined in Table 1 and the aggregation of Mississippi Valley adults that appear in Table 3. The totals for each of these groups, involving 2883 and 3033 birds respectively, differ in their 5 monthly frequencies as follows:

	Sept.—	*Oct.*—	*Nov.*—	*Dec.*—	*Jan.*
Table 1	7.3—	20.3—	44.2—	22.5—	5.8
Table 3	6.1—	30.9—	36.0—	21.8—	5.3

There was only minor duplication in these samples (involving somewhat less than 200 Manitoba and Saskatchewan birds). The two groups differ importantly in their geography and also as to the times they were exposed to hunting, birds in Table 1 being essentially plains and coastal inhabitants banded mostly in the 1930s, while those in Table 3 are more eastern and were shot mostly in the 1940s. I did not attempt in this study to determine what factors actually governed the differences in mortality here noted. (The extremely large numbers of duck stamps annually sold in the Upper Mississippi Valley surely implies that the early-season kill in this region may be relatively heavier than that found on the Pacific Coast.) It is once more clear, however, that the monthly variation in hunting mortality encountered by mallards is very much a dynamic phenomenon and not a static one.

Current waterfowl research is emphasizing the summer banding of large numbers of juvenile and adult waterfowl on the Canadian breeding grounds. Whenever the reported percentage shot by hunters importantly varies in the first season after banding, the effect of hunting regulations and weather should be studied by correlating these recovery rates with peak flights recorded by field observers and with variations in the monthly distribution of the banded birds that are reported shot. From a management standpoint, the most valuable banding data are those acquired from birds captured on the main

breeding grounds of a species. The next most valuable, I believe, are those obtained from banding operations on the main wintering grounds. In both cases annual census data presumably will help us in understanding the population dynamics of these valuable game birds.

SUMMARY

1. This study of the monthly frequency of hunting mortality reported for banded mallards explores the possibility of obtaining data that will aid in analyzing the effect of weather upon the harvest of waterfowl populations.

2. For 2883 western adult birds shot mostly in the 1930s, there was a unimodal distribution of the records for the five months of the hunting season, the peak (44%) occurring in November. For 3033 Mississippi Valley adults, shot mostly in the 1940s, the peak of the kill (36%) also occurred in this month, but October (31%) involved a relatively important share of the records.

3. Overall monthly frequencies of hunting mortality among 610 young birds were heavily skewed toward the earlier part of the hunting season, 45% of the kill occurring in September and October. The extent of this skewness displayed a geographical gradient according to the latitudes in which the birds were banded.

4. Marked differences in the chronological pattern of the kill occurred from one year to another. These variations would appear to be objective criteria by which we can determine how weather affected the kill under a given set of hunting regulations.

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THE RELATIVE STRENGTHS OF WHITEFISH YEAR CLASSES AS AFFECTED BY EGG PLANTINGS AND WEATHER[1]

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Introduction

In October, 1946, the author published the results of the study of the efficiency of a whitefish hatchery in Alberta (Effectiveness of a whitefish hatchery. Jour. Wild. Mgt. **10** (4): 316-322; 1946); this study included data gathered from 1941 to 1945, inclusive, and covered the first five years of a long term study of year class strengths in six whitefish producing lakes. In 1944 the hatchery being tested made its last plantings of 'eyed' eggs. Survivors of these plantings are now six-year-olds; beyond this age they will appear only in insignificant numbers in the fishery. It seems advisable, therefore, to analyze what data are available since 1945 and terminate the study. In order that this paper may be complete in itself, the full ten years of data, 1941-1950, are presented. Also, data from a seventh lake, Lake Wabamun, have been added.

The plan of the investigation has been to compare the strengths of whitefish year classes which have been supported by hatchery plantings with those which have not been so supported. Seven lakes have been used in the belief that they would provide mutual controls, i.e., eliminate errors resulting from coincidence or pure chance. The lakes (Figure 1) are scattered over a large section of Alberta between 53° and 56° North latitude and 110° and 116° longitude. They vary from twelve to over four hundred square miles in area.

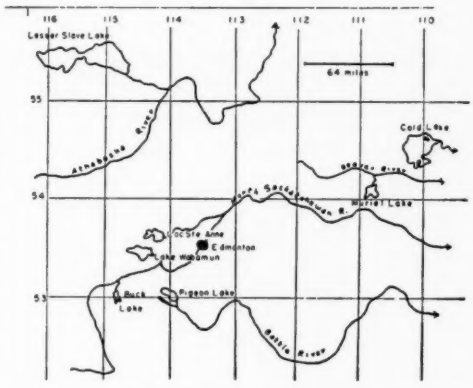

FIG. 1. Map showing the location of the seven lakes studied.

Material and Methods

The investigation consisted of collecting samples of whitefish each year from the seven lakes. The ages of the fish in these samples were determined from their scales; then each fish was assigned to its year class. The samples were now expressed in terms of the percentage abundance of each year class; e.g., a sample collected in 1945 and containing 30, 40 and 30 three-, four- and five-year-olds, respectively, would be recorded as thirty percent

[1] I am very much indebted to Mr. H. B. Watkins, Superintendent of Fisheries for the Alberta Government, who arranged to have his field officers collect the whitefish scales and measurements which were used in this study.

year class 1942, forty percent year class 1941 and thirty percent year class 1940. Over a period of years the data give a picture of the percentage or relative abundance of each year class during the years it appeared in the fishery (usually as three-, four-, five-, six- and seven-year-old fish). In order to be sure that the samples were representative of what the commercial fishery was taking, only commercial gear, 5½ inch mesh gill nets, was used to collect the samples.

When the relative strengths of the different year classes had been determined in the manner just described, the hatchery record was examined to see if the year classes which had received hatchery support were, in general, stronger than those which had not; if the hatchery is doing its job the hatchery supported year classes should, of course, be relatively stronger.

In my report of the first five years of this study the percentages of each year class found in the samples were converted into numbers of fish by (1) assuming the sample for each lake for each year was representative of the age composition of the fish taken in the commercial fishery; (2) by determining the average weight of a single fish of each group; and, (3) from the catch statistics (total weight), calculating the weight and then numbers of each age group in the catch. This method has been abandoned, largely because it multiplies the possibility of error; the accuracy of the work depends solely on the reliability of the percentages determined from the samples; further, the catch statistics are reported for calendar years, whereas the year class years run from about June 1st to May 31st (time of annulus formation in this latitude); finally, the catches from these lakes are controlled by quotas so that actual numbers of fish of each year class are of less value than relative numbers. In this paper the percentages of the year classes appearing in the samples are used directly for comparisons, with no attempt to convert them to numbers of fish taken in the fishery.

Table 1 shows the lakes studied, their areas and the number of fish taken each year as samples. The distribution of the 13,062 whitefish used for age determination is not as good as desirable; too few were taken in earlier years and there are a few breaks in the data where no samples were taken. However, the

TABLE 1.—LAKES STUDIED AND NUMBERS OF WHITEFISH REMOVED FOR SAMPLES OF YEAR CLASS STRENGTHS

Lake	Area (sq. miles)	Number of fish taken each year *										
		1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	Total
Lesser Slave	462	109	95	134	490	500	0	601	500	500	500	3,429
Cold	140	19	80	48	314	196	237	402	101	0	100	1,497
Wabamun	25	34	83	665	197	201	200	558	224	315	190	2,667
Ste. Anne	25	0	18	74	129	200	0	210	202	144	207	1,184
Pigeon	40	0	100	330	173	102	301	215	92	100	127	1,540
Buck	12	0	16	465	87	101	201	242	151	0	165	1,428
Muriel	25	0	43	70	66	175	200	328	185	150	100	1,317
												13,062

* The years are year class years, i.e., 1941 means June, 1941, to May, 1942.

samples are random; they were taken at different times of the year and each individual sample is usually the result of combining several smaller samples taken in different areas of the lakes. As all age determinations were made by the author, the size of samples was restricted to some degree by the time available to examine them.

Table 2 summarizes the activities of the whitefish hatchery; in it the years in which each of the studied lakes was planted, and the sizes of the plantings are shown. Most of the plants have been of eyed eggs. That these hatch and produce fry was shown in my previous paper on the hatchery. The question will be further discussed in the account of Muriel Lake in this paper. The distribution of the plantings leaves much to be desired. It would have been better if each lake had been planted in alternate years and that was the original plan. Weather conditions and local pressures made adherence to this scheme impossible.

In the account to follow, the data obtained for each lake will be discussed in turn; then the year class strengths in all the lakes will be considered.

LESSER SLAVE LAKE

Lesser Slave Lake is the largest of the seven studied. Over the period 1941 to 1950, 3,429 whitefish were taken for samples of the age composition of the population. The year classes 1932-1946, inclusive, are represented in the samples. Of these, 1938-1944, inclusive, are present in the samples as three-, four-, five- and six-year-olds; these are the ages when each year class makes its greatest contribution to the fishery. In Table 3 the strengths of these seven year classes are shown, together with the plantings made in the same years from the hatchery. Table 3 is interpreted in this way: the fish hatched in 1938 were taken as three-year-olds in the 1941 sample; they made up 2.7 percent of the sample; the same fish were taken in the 1942 sample as four-year-olds and made up 15.9 percent of the 1942 sample; and so on for the other ages and year classes. A rough idea of the strength of the year classes has been obtained by adding the percentages together. The blanks in the table are due to the absence of a sample for 1946. If the strengths of the seven year classes are compared to the size of the hatchery planting, it is readily apparent that no correlation exists. Thus 1939 is stronger than 1938 although it received less than a third as much hatchery support; 1942 is very weak and that year the hatchery support was small, but 1944, strongest of all, received no support whatever.

TABLE 2.—PLANTINGS OF WHITEFISH EGGS OR FRY (IN MILLIONS) IN SEVEN ALBERTA LAKES

Lake	1937	1938	1939	1940	1941	1942	1943	1944
Lesser Slave	89[1]	61[1]	18	41[2]	30	6	60	0
Cold	0	3	2	5	0	5	0	5
Wabamun	0	5	2	5	6	5.9	0	4
Ste. Anne	0	5	4	2	0	4	0	2
Pigeon	0	4	3	5	0	4	0	4
Buck	0	0	0	0	1	4	0	1
Muriel	5	0	1	1	0	1	0	1

[1] Fry
[2] Includes 2.5 million fry

TABLE 3.—A COMPARISON OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1938–1944, INCLUSIVE, OVER THE AGES 3–6, IN LESSER SLAVE LAKE, TOGETHER WITH HATCHERY SUPPORT IN MILLIONS OF EGGS OR FRY

Year Class	Hatchery Support	Age 3	4	5	6	Total
1938	61[1]	2.7	15.9	29.8	8.0	56.4
1939	18	20.0	33.0	22.0	24.2	99.2
1940	41[2]	12.0	41.7	37.2	..	+90.9
1941	30	10.4	20.8	..	4.0	+35.2
1942	6	0.4	..	8.1	8.6	+17.1
1943	60	..	59.1	24.2	18.6	+101.9
1944	0	23.1	52.6	70.0	16.4	162.1

.. No data
[1] Fry
[2] Includes 2.5 million fry

The three weaker year classes received, on the average, as much hatchery support as the four stronger year classes.

Data for the year classes 1936 and 1937 are available over the ages 5-11 inclusive (with age 9 absent in one and age 10 in the other). Their strengths (calculated in the same way as the 1938-1944 year classes) amount to 73.3 and 56.0, respectively. Thus 1936 is the stronger though it received no hatchery support and 1937 received 89 million fry.

The data for Lesser Slave Lake show no evidence that the hatchery has had an effect on year class strength.

COLD LAKE

Cold Lake is smaller than Lesser Slave, but very much deeper and colder. As a result, its whitefish grow more slowly and the year classes making up the samples cover an earlier period. A total of 1,497 whitefish was used. The data permit the comparison of the relative strengths of the year classes 1936-1940 over the ages 5-9 and of the year classes 1940-1943 over the ages 3-6. These comparisons are shown in Table 4.

A study of Table 4 reveals a large variation in year class strengths which may not be correlated with hatchery support or its lack. In the series 1936-1940, 1938 is the weakest year class, yet it received support of 3 million eyed eggs; 1937, an unsupported year class is stronger than 1938 or 1939, both of which received support; of the two strongest, 1936 and 1940, one received support and one did not. Similarly, in the series 1940-1943, both the strongest

TABLE 4.—COMPARISONS OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1936–1940 OVER THE AGES 5–9 AND OF THE YEAR CLASSES 1940–1943 OVER THE AGES 3–6 IN COLD LAKE, TOGETHER WITH HATCHERY SUPPORT IN MILLIONS OF EGGS

Year Class	Hatchery Support	Age of Capture 3	4	5	6	7	8	9	Total
1936.....	0	..	..	0	2.5	16.0	30.0	22.5	71.0
1937.....	0	..	..	2.5	2.1	9.9	27.0	1.7	43.2
1938.....	3	..	..	0	1.9	13.3	8.0	4.7	27.9
1939.....	2	..	..	0.3	9.2	11.7	10.0	5.0	36.2
1940.....	5	0	0	2.6	33.9	17.2	19.0	2.0	74.7
1940.....	5	0	0	2.6	33.9	..	..	..	36.5
1941.....	0	0	10.7	31.2	41.5	..	..	..	83.4
1942.....	5	2	5.5	21.5	37.0	..	..	..	66.0
1943.....	0	2.2	0.7	12.0	19.0	..	..	..	31.7

.. Indicates no data.

and the weakest (1941 and 1943) received no hatchery support.

The general conclusion from the Cold Lake data is that no effect of hatchery plantings may be demonstrated.

LAKE WABAMUN

Lake Wabamun is a warm, shallow lake which produces large yields of high quality, fast-growing whitefish. A total of 2,667 whitefish was used in this study. The data permit the comparison of the relative strengths of the year classes 1937-1944 over the ages 3-7; this is shown in Table 5.

A study of the data in Table 5 shows first, a large variation in year class strength. Of the eight year classes compared, six received hatchery support and two did not; these unsupported year classes, 1937 and 1943, constitute one of the strongest and one of the weakest of the series. Among the supported year classes, 1939 is the strongest, but it received the smallest planting of eyed eggs; the other five supported year classes received from 4 to 6 million eyed eggs, i.e., about the same support, yet their strengths vary by some six hundred percent. As with Lesser Slave and Cold Lakes, the conclusion is inevitable; there is no evidence that the plantings from the hatchery have had any effect.

LAC STE. ANNE

Lac Ste. Anne is a warm, shallow lake with an area of approximately twenty-five square miles. It supports a large, fast-growing whitefish population. A total of 1,184 whitefish has been used for samples; these were taken over the years 1942-1950 inclusive (1946 omitted). The data allow the comparison of the year classes 1938-1943 over the ages 4-7 and the year classes 1940-1946 over the ages 2-5. These comparisons are shown in Table 6, together with the egg plantings made from the hatchery.

In the first series (1938-1943) both the strongest and the weakest year classes received hatchery support; an unsupported year class (1943) is almost as strong as the most heavily supported (1938); there is no relation between size of planting and strength of year class. In the second series (1940-1946), the weakest year class (1942) received the

TABLE 5.—COMPARISON OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1937–1944 OVER THE AGES 3–7 IN LAKE WABAMUN, TOGETHER WITH THE HATCHERY PLANTINGS IN MILLIONS OF EGGS

Year Class	Hatchery Support	Age at Capture					Total
		3	4	5	6	7	
1937.....	0	..	69.2	45.8	8.9	4.1	+128.0
1938.....	5	0	43.4	38.9	32.0	23.4	137.7
1939.....	2	4.8	48.6	52.3	57.6	16.0	179.3
1940.....	5	3.6	11.7	15.4	45.5	46.7	122.9
1941.....	6	0	0.5	18.0	19.0	22.3	59.8
1942.....	5.9	0	11.0	3.6	5.8	9.8	30.2
1943.....	0	4	1.8	4.1	4.4	7.4	21.7
1944.....	4	0.7	6.7	4.1	4.7	..	+16.2

.. Indicates no data.

TABLE 6.—COMPARISON OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1938–1943 OVER THE AGES 4–7 AND OF THE YEAR CLASSES 1940–1946 OVER THE AGES 2–5 IN LAC STE. ANNE, TOGETHER WITH THE HATCHERY PLANTINGS IN MILLIONS OF EGGS

Year Class	Hatchery Support	Age at Capture 2	3	4	5	6	7	Total
1938.....	5	..	..	16.7	43.3	21.2	18.0	99.2
1939.....	4	..	..	6.8	22.4	17.0	..	+46.2
1940.....	2	..	..	18.8	17.0	..	2.0	+37.8
1941.....	0	..	..	21.5	..	4.3	1.5	+27.3
1942.....	4	..	..	..	4.3	4.5	0	+8.8
1943.....	0	..	..	50.0	40.0	4.9	0.5	95.4
1940.....	2	0	0	18.8	17.0	..	..	35.8
1941.....	0	0	11.2	21.5	..	..	..	+32.7
1942.....	4	0	18.0	..	4.3	..	..	+22.3
1943.....	0	0	..	50.0	40.0	..	..	+90.0
1944.....	2	..	37.1	35.0	4.8	..	..	76.9
1945.....	0	0	6.0	34.7	8.0	..	..	48.7
1946.....	0	0	55.5	78.0	..	..	..	+133.5

most support; the two strongest year classes (1943 and 1946), received no plantings.

As with the other lakes, the Lac Ste. Anne data show that the activities of the hatchery had no visible effect on the year class strengths.

PIGEON LAKE

Pigeon Lake, with an area of approximately forty square miles has supported a commercial whitefish fishery since 1918; it is a warm, shallow, sandy lake. A total of 1,540 whitefish has been taken for samples; these cover every year of the period 1942-1950. The best comparisons are of the year classes 1939-1945 over the ages 2-6; these are shown in Table 7, together with the plantings of eggs from the hatchery.

The strongest year class is that of 1945; it received no hatchery support. The weakest year class is that of 1943 which also was unsupported. Of the remaining year classes, 1941, which received no support, is stronger than 1942 and 1939, and weaker than 1940, all of which did receive support.

Again, the conclusion is inescapable; the data fail to demonstrate any hatchery influence.

TABLE 7.—COMPARISON OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1939–1945 OVER THE AGES 2–6 IN PIGEON LAKE, TOGETHER WITH THE HATCHERY PLANTINGS IN MILLIONS OF EGGS

Year Class	Hatchery Support	Age at Capture 2	3	4	5	6	Total
1939.....	3	..	2.0	34.5	23.1	8.8	+68.4
1940.....	5	8.0	34.0	38.5	23.5	7.6	111.6
1941.....	0	0	5.4	52.9	13.6	0.5	72.4
1942.....	4	0	11.8	40.3	0.5	0	52.6
1943.....	0	0	21.6	3.3	2.3	1.0	28.2
1944.....	4	13.3	20.9	4.3	23.0	0.7	62.2
1945.....	0	74.4	32.6	49.0	9.5	..	+165.5

.. Indicates no data.

BUCK LAKE

Buck Lake, with an area of twelve square miles, is the smallest of the series. If the hatchery has any effect on year class strength, it should be most easily seen in this small lake. Buck is a warm, rich lake, at the peak of eutrophy; it has produced high quality, fast growing whitefish for many years. A total of 1,428 whitefish has been taken as annual samples over the years 1942-1950 inclusive, except 1949. The data permit the comparison of the relative strengths of the year classes 1939-1944 over the ages 2-7; these comparisons, together with the hatchery plantings, are shown in Table 8.

Of the six year classes compared in Table 8, three have received support from the hatchery and three have not. It is somewhat surprising to observe that the three supported year classes are weaker than the weakest of the three unsupported year classes. A study of these data, without reference to other lakes, would suggest that the hatchery has been detrimental. This is, of course, absurd, and the data must be accepted merely as further evidence that the hatchery plantings are ineffective.

MURIEL LAKE

Muriel, a clear, sandy lake, of twenty-five square miles area, is of special interest in this study because it originally contained no whitefish. Whitefish were first planted, as eyed eggs, in 1937. The first sample was taken in February, 1943; the scales of these fish were sent to the author who determined the ages before he knew that all the fish had to belong to the 1937 year class; all the fish were pronounced five-year-olds, a heartening confirmation of the accuracy of the scale method.

Egg plantings were made in Muriel Lake again in 1939, 1940, 1942 and 1944. The finding of any year classes other than these would constitute proof of the establishment of a spawning population. A total of 1,317 whitefish has been taken as samples over the years 1942-1950, inclusive. All of these data are presented in Table 9, together with the history of hatchery plantings.

A study of Table 9 shows that the two hatchery plantings of 1939 and 1940 survived and contributed to the fishery for nine years (at ages 3-11); of special interest is the evidence that a year class of 1941 was hatched and showed

TABLE 8.—COMPARISON OF THE RELATIVE STRENGTHS OF THE YEAR CLASSES 1939–1944 OVER THE AGES 2–7 IN BUCK LAKE, TOGETHER WITH THE HATCHERY PLANTINGS IN MILLIONS OF EGGS

Year Class	Hatchery Support	Age at Capture						
		2	3	4	5	6	7	Total
1939.....	0	..	0	7.5	16.3	30.0	11.5	+65.3
1940.....	0	12.2	45.0	33.7	40.0	26.0	16.5	173.4
1941.....	1	0	3.5	10.0	12.0	8.8	5.3	39.6
1942.....	4	0	3.0	15.0	28.5	10.6	..	+57.1
1943.....	0	0	32.0	35.0	29.0	..	3.6	+99.6
1944.....	1	1.0	1.2	22.0	..	3.1	..	+27.3

.. Indicates no data.

TABLE 9.—THE YEAR CLASSES AND AGES AT CAPTURE OF 1,317 WHITEFISH FROM MURIEL LAKE TAKEN OVER THE PERIOD 1942–1950; FIGURES ARE PERCENTAGES; THE HATCHERY PLANTINGS ARE ALSO SHOWN

Year Class	Hatchery Support (millions)	Age at Capture									
		2	3	4	5	6	7	8	9	10	11
1937.....	5	..	..	..	100.0	8.6	3.0	0	0	0	1.1
1938.....	0	..	..	0	0	0	0	0	0	4.8	0
1939.....	1	..	0	83.0	65.0	8.0	10.0	4.0	20.5	0.6	1.0
1940.....	1	0	8.6	32.0	82.3	36.0	13.0	23.2	17.3	1.0	..
1941.....	0	0	0	5.7	36.0	39.6	22.5	17.3	17.0	..	..
1942.....	1	0	2.9	17.0	33.6	13.5	13.3	11.0	..	..	..
1943.....	0	1.1	1.5	9.5	6.5	13.2	16.0	..	..	..	..
1944.....	1	0	0.3	3.8	18.0	25.0	..	..	..	..	..
1945.....	0	0	3.8	17.3	7.0	..	..	..	..	..	..
1946.....	0	0	2.0	7.0	..	..	..	..	..	..	..
1947.....	0	0.7	15.0	..	..	..	..	..	..	..	..

.. Indicates no data.

strongly in the samples as 4-9 year-old fish. This year class must have resulted from the natural reproduction of the 1937 planting. Similarly, year classes 1943 and 1945-1947 must also be the result of natural reproduction. These findings serve as proof that plantings of eyed eggs survive; but it is of considerable importance to note that the year class of 1941, which resulted from natural reproduction of a *single year class* is stronger than the year class of 1942 which received hatchery support.

A secondary point of interest in these data is the assigning of nine fish, caught in 1948, to age group ten, which places them in the year class of 1938; this is an impossible situation as there are no fish of this year class in Muriel Lake. It means that error in scale reading does occur in the older fish; that this error is not extensive is shown by the failure to assign other fish to this year class.

SURVEY OF YEAR CLASS STRENGTHS IN ALL THE LAKES

The examination of the data from each lake, which has just been concluded, has led to the conclusion that the plantings of eggs from the hatchery have not affected the strengths of the whitefish year classes. The data have shown, however, that there is considerable variation in the strengths of the year classes. It would be of interest to determine if these variations are random or if they seem to follow some particular pattern. Accordingly, Figure 2 has been prepared. In drawing up this figure, all the data except those from Cold Lake have been used. In Cold Lake whitefish growth is so slow that the year classes represented in the sample belong, for the most part, to years earlier than those from the other lakes; the Cold Lake data are, therefore, not strictly comparable. The figure shows the record of each of the year classes 1935-1945, inclusive, for each of six lakes. This figure has the following meaning: the first vertical column shows the year class in Buck Lake, the second in Pigeon Lake, the third in Lake Wabamun, etc. Let us select the year class 1939 as an example; in Buck Lake this year class made up 7.5 percent

of a sample as four-year-olds, 16.3 percent as five-year-olds, 30 percent as six-year-olds, 11.5 percent as seven-year-olds, 8.4 percent as eight-year-olds, etc.; the maximum ordinal value which the graph permits is 64 percent. Where an ordinate exceeds 64 percent the figure is printed.

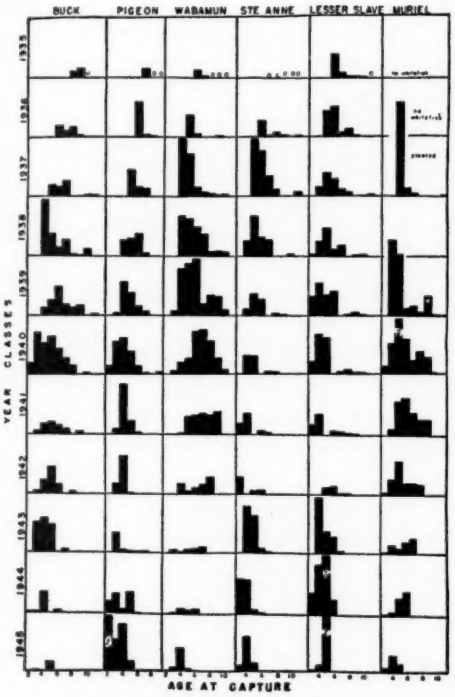

FIG. 2. The relative strengths of the whitefish year classes 1935-1945, inclusive, in six lakes. (Explanation in text.)

Figure 2 permits a visual comparison of the relative strengths of all the year classes in the different lakes. A rather surprising uniformity is evident; the year class of 1935 is universally weak; 1936 is a little stronger; 1937 is considerably stronger. The strengths of the year classes increase from 1937-1940, except in Lac Ste. Anne where 1939 and 1940 are a little weaker. Then, in all the lakes (even Muriel, in which the whitefish began with the year class of 1937), a decline in strength began with the year class of 1941; a minimum was reached with the year class of 1942. The year classes 1943-1945 show a slow recovery of strength except in Lake Wabamun, where the minimum was lowest and recovery appears to be slower.

This gradual rise and then fall in year class strengths is a very striking phenomenon, especially since it is more or less coincident in six different, scattered lakes, of diverse sizes and unconnected by rivers. It suggests, rather strongly, that the cause must be some all-pervading factor in the external environment, operating throughout the country and not just in individual lakes. It is obvious that meteorological conditions could be the explanation.

THE POSSIBLE INFLUENCE OF WEATHER

A little thought on the possible effect of weather on year class strength leads to the conclusion that vulnerability to weather conditions is mainly during spawning time, September, October and November; it is not the adults which are affected but the eggs which they deposit in shallow water. The eggs could be affected by temperature, by precipitation and by wind. Later, in the spring, the fry might also be affected, but our observations have taught us that whitefish eggs hatch, in these latitudes, while the ice cover is still intact, so that they are comparatively immune to weather. Undoubtedly there are conditions which affect fry survival after hatching—one of these might be the abundance of entomostraca. But,

as no data are available, the possibility cannot be investigated.

Records of the Dominion Meteorological Station at Edmonton were consulted and data on precipitation, temperatures and winds for the months of September, October and November were abstracted for the years 1935-1945. These data are for Edmonton; no data are available for localities any closer to any one of the six lakes under investigation. This is not a serious drawback as the lakes have been shown to be generally similar as far as whitefish year class strength variation is concerned. Consequently, whatever causes variations must be operative over the whole territory at the same time. Edmonton is central for the area and its weather should be roughly applicable throughout.

Temperature. Mean monthly minima and also absolute minima were studied. There is considerable variation in these, especially in November; but the variations fail to correspond to variations in year class strength. For example, unusually high temperatures in the falls of 1939 and 1943 were followed by a strong year class in the former and a weak one in the latter year. Low temperatures in 1937 and 1940 were followed by strong year classes; in 1942 low temperature was followed by a weak year class. In view of the complete absence of any correlation, the temperature data are not published.

Precipitation. Fall rain and snow have also been extremely variable. September and October total precipitation has varied up and down erratically; the variations fail to correspond with the variations in whitefish year class strength. November precipitation is also variable; in this case there is a certain amount of agreement with variations in the year classes. Thus, heavy precipitation is associated with a weak year class in 1935 and in 1942. Fairly low precipitation in November of 1936-1939, inclusive, is associated with strong year classes. Exceptions are provided by 1940, where fairly heavy precipitation is followed by a strong year class, and 1943, where practically no precipitation is followed, in three of the lakes, by very weak year classes. There is, then, some evidence of an inverse relationship between precipitation and year class strength; but, as some of the data do not agree with this hypothesis, it cannot be accepted as anything more than a suggestion.

Wind. Data are available which give the total mileage of wind each month, the prevailing direction, the number of gales and the maximum speed reached in miles per hour. The prevailing wind of this area is northwest. The months when the prevailing wind was not northwest are too few to be worthy of consideration. Therefore, only total mileage of wind and wind speeds have been studied. Figure 3 is a graph of total wind mileages during September, October and November over the years 1935-1945 (data for November, 1940, are not available). Considerable variation is evident; this variation corresponds rather well with variation in whitefish year classes. High winds in 1935 and 1936 were followed by weak year classes; the relatively calm period of 1937-1940 produced four strong year classes; high winds again in 1941-1945 have been followed by generally weak year classes. However, the correlation would be stronger if it had been less windy during 1943-1945.

An examination of the maximum wind speeds each month gives the same picture; i.e., months with high total mileage of winds also had high maximum wind speeds. The occurrence of gales is also suggestive; in 1935-36 during September, October and November there were twelve gales; no gales were recorded during these months from 1937-1940; there were two gales in 1941, one in 1942 and two in 1943.

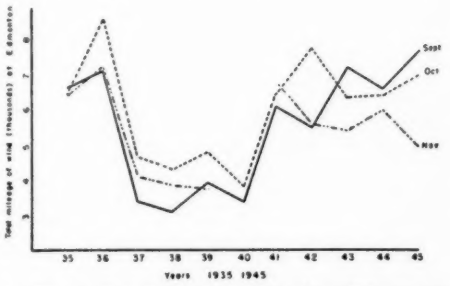

FIG. 3. Total mileage of winds at Edmonton during each of the months September, October and November during the years 1935-1945.

The rather meagre weather data available suggest, in summary, that temperature is of no consequence; that precipitation during November may have some effect; and that winds are probably important in influencing whitefish year class strengths, although the matter is by no means conclusively demonstrated. The manner in which wind operates is known from our observations on Calling Lake (not one of the lakes covered in this paper). Calling Lake has had several very severe year class failures in its whitefish which could be attributed to autumns when strong north and northwest winds actually rolled huge windrows of eggs upon the beaches. The morphometry of Calling Lake makes it unusually liable to such wind effects, so that the windrows of destroyed eggs represent extreme conditions; but, in any lake, it is conceivable that eggs in shallow water could receive considerable battering without being actually rolled out on shore. Furthermore, high turbidity, which strong winds cause, might, when calm returns, smother the eggs in silt. Heavy precipitation would enhance the turbidity; this may account for the apparent association of high November precipitation with weak year classes.

SUMMARY AND CONCLUSIONS

(1) Over the period 1941-1950 a total of 13,062 whitefish scales has been read; the whitefish were collected in small samples, annually, from each of seven Alberta lakes.

(2) The lakes lie between 53° and 56° North latitude and 110° and 116° longitude; they vary from twelve to nearly five hundred square miles in area.

(3) The ages of the fish making up the samples from each lake were used to determine the relative strengths of the year classes of 1935-1945 (in a few cases, to 1947).

(4) The relative strengths of the year classes are compared to the hatchery record; i.e., none of the lakes received egg plantings every year; consequently, it is possible to determine if supported year classes tend to be stronger than non-supported year classes. No such tendency is demonstrable.

(5) Muriel Lake is of special interest as it contained no whitefish until it was planted with eyed eggs in 1937. These survived, matured and produced strong, 'natural' year classes.

(6) The study proves conclusively that year class strength is completely unaffected by plantings from the hatch-

ery in lakes where a spawning population exists.

(7) A remarkable similarity in the variation of the year classes of six of the lakes was observed; thus, year classes were weak in 1935-36, strong from 1937-1940 and generally weaker in 1941, 1942 and 1943.

(8) Somewhat limited meteorological data on temperatures, precipitation and winds were studied in a search for an explanation of this year class 'cycle.' No conclusive findings were made but there is a reasonable suggestion that year class strength may be inversely correlated with strength of winds.

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ASPARAGUS AS EMERGENCY PHEASANT FOOD

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During the yearly life cycle of pheasants in the Northern states there are two periods of emergency which may cause a departure from the normal food-habits pattern. The first of these occurs during the hunting season, when departure is normally slight; the second occurs during severe winter.

An emergency winter food should meet as many of the following requirements as possible. It should be perennial, it should furnish cover, its seed crop should be abundant and persistent, the plant should stand erect through snow, it should maintain weight, vitality and resistance (Leopold, *Game Management*, p. 259), and it should have a financial value to the farmer and still make itself available as a winter food. Multiflora rose is one of the few plants fulfilling all these requirements. While it does not furnish a cash income to the farmer it eliminates the necessity of expensive fence maintenance.

The only other plant known to the writer that meets all these requirements is asparagus (*Asparagus officinalis*). In addition it apparently meets the even more stringent requirement of not being utilized except in time of emergency. This is extremely important since 'winter' food patches of palatable foods often are entirely eaten before snow comes. It is not known if asparagus would be utilized prior to emergencies if it were present only in isolated and small patches but it is believed that necessity governs its utilization.

That hunting seasons may be considered periods of emergency is supported by the following data. A male pheasant collected in hunting season on October 19, 1949 had as its crop contents 94 per cent *Crataegus* sp. and 6 per cent *Orthoptera*. This represents a definite departure from normal food habits. *Crataegus* is seldom taken in this area in quantity except in time of heavy snow. When hunting pheasants in the large side canyons away from the asparagus plantings on the Tucannon River (Columbia County, southeastern Washington), the writer has found pheasant droppings containing asparagus seeds. These pheasants fed on asparagus berries while temporarily 'pinned down' in the heavily hunted asparagus fields. Generally pheasants inhabiting aspara-

gus fields do not feed on asparagus in hunting season as has been shown by intensive study of crops collected from these areas.

Of more importance is the fact that several crop collections made immediately prior to hunting season and between the end of hunting season and the onset of snow failed to show any utilization of asparagus. Similarly, with the snow recession, use of asparagus decreases rapidly as other foods become available. Thus it is indicated that asparagus is not heavily utilized except to some extent in hunting season and, more particularly, in winter emergency periods when heavy use is common.

Asparagus officinalis is a member of the family *Liliaceae*. The fruit is a red berry having three to six black seeds, with five seeds occurring most frequently. The early succulent spring shoots are cut for market or for commercial canning after which time the shoots are allowed to develop tops which at maturity reach a height of four to ten feet. Columbia County's commercial fields are commonly planted in four foot rows with the plants spaced 18 inches apart in the row. In the October hunting season a large setter cannot be seen in the dense cover of an asparagus field.

Asparagus is a plant which thrives best on a deep, sandy loam soil but the commercial plantings in Columbia County succeed on a river-bottom silt-deposit soil. The plant must have good drainage. Commercial plantings of asparagus in this area are commonly irrigated. At present there is one field on the Whetstone Creek in Columbia County, southeastern Washington (Sect. 7, T 10 N, R 39 E) which is cut for the cannery but which is not irrigated. This field lies in the 18 inch average rainfall belt. Thus it seems possible that with proper early cultivation techniques asparagus plantings for pheasants could be widely established in the 20 inch rainfall belt; they could of course be established easily in more humid areas.

In 1924 that part of the Pasco Irrigation District lying east of Pasco in Franklin County was discontinued. To the present day a small patch of asparagus survives along the main highway between Pasco and Burbank, although this area lies in a seven to eight inch average rainfall belt. This planting was established under irrigation but its survival illustrates the persistence of the plant under adverse conditions.

As has been indicated above, asparagus is a perennial, requiring three years to reach early maturity. It produces excellent cover which deteriorates slowly by weathering action. Although wind and snow action may break the stalks the resultant canopy affords excellent cover in conjunction with food. Often this canopy is instrumental in allowing ground gleaning of *Echinochloa crus-galli* and *Solanum villosum* as well as other weed seeds if the snowfall has not been too heavy. This is desirable because any variation from a straight asparagus seed diet is probably beneficial. The number of berries on each plant varies greatly.

Utilizing berries picked by the writer, L. A. Wadkins, in January and February, 1947 (unpublished manuscript, Washington State College) force fed pheasants for a period of 35 days on a straight diet of asparagus berries. During this time the minimum temperature

was 18° F, maximum was 44° F with a mean temperature of 31° F. At the end of this time the birds showed an average daily loss of 3.4 grams. Compared to the other foods used in the experiment, asparagus was superior to *Rosa multiflora*, *Crataegus sp.*, *Robinia pseudoacacia* and *Symphoricarpos sp.*; it was inferior to peas and the control scratch.

Perhaps the most important characteristic of asparagus is the fact that after early shoots are harvested the plant is allowed to grow tops, thus furnishing income for the farmer and food and cover for pheasants. This desirable aspect is partially nullified by the practice of fall disking the tops, which is now becoming prevalent in this area.

Pheasants will readily take new types of food when necessity demands. This was shown when a small, unharvested field of safflower on McKay Creek in Columbia County was completely utilized three days after the snow became crusted in January, 1950. This was the first safflower planted in the area.

No collections of valley quail were made so it is not known if they use asparagus berries. It is probable that some song birds take it in quantity. Coyotes often eat asparagus berries in winter. When following coyote tracks in fresh snow the writer as a boy at Pasco in Franklin County often found scats composed primarily of such berries. The red fruit coat and the black seeds were often present in winter scats. Apparently the small amount of pulp was all that was digested. A somewhat similar utilization is apparent in pheasants.

On examination asparagus seed does not seem to be appreciably harder than wheat. However, the intestines of a pheasant feeding on asparagus are filled with many undigested seed fragments. The caecum is large, inflated and filled with a liquid reddish mass derived from the hull of the asparagus berry. From the lack of grit in the gizzards of the pheasants shown in Table 1 it seems that the asparagus seed acts as a grit substitute. No specimen has been found containing a large amount of grit so it is not known if greater amounts of grit would increase the rate of digestion of the seed. It is possible that such seeds as asparagus and *Crataegus* would have a grit flushing, or more probably, a grit utilizing action. Further controlled-pen force feeding experiments with and without grit, are needed as well as physiological examination, particularly of the caeca.

It is noteworthy that as utilization of asparagus seed decreases the undigested fragments remain in the gizzard as a grit substitute. This is indicated by lack of asparagus seed in the crop and also by the caecum which is no longer grossly inflated and which does not contain the reddish liquid mass previously described.

Bob Jackson, longtime resident and sportsman of the Tucannon River originally brought asparagus feeding by pheasants to the writer's attention. He states that in the fall he stops feeding his chickens and allows them to run free in the asparagus field to feed and that when killed they are fat and in excellent shape.

The final evaluation of any pheasant food depends on the pheasant's condition after using such food. The fol-

TABLE 1.

CVS Spec. No.	Date	Crop Contents in cc.			Gizzard Grit	Remarks
		Asparagus	*Echinochloa*	Other		
117.....	12/14/48	23	6	0.6–	tr.	new snow
119.....	12/26/48	17	21	5.	1 cc	snow tr.
120.....	12/26/48	8	6.5	2	tr.	snow tr.
132.....	2/1/50	42	..	3	0.5 cc	snow 6″
133.....	2/1/50	25	..	tr.	none	gizz. asp.
134.....	2/17/50	0	..	..	tr.	gizz. asp. 2.7 cc.
135.....	3/25/50	tr.	..	22	tr.	gizz. asp. 1.5 cc.

lowing detailed notes indicate this condition in pheasants; specimen number 132 had plentiful clear yellow fat reserves when collected on February 1, 1950. It had 245 berries in its crop. Specimen number 133 was collected five miles up the Tucannon River from 132 on the same day. This location is at a higher elevation with greater snow depth. The bird's fat reserves were depleted and had just begun to exhibit an orange tinge. Specimen number 134 collected at Huntsville on the Touchet River, February 17, 1950 showed fat reserves plentiful and clear yellow.

The results of pheasant feeding on a field of asparagus along the Tucannon River which had been fall disked were clearly evident. That the pheasants utilized this asparagus in preference to other emergency foods such as *Crataegus, Prunus, Rosa, Symphoricarpos, Dipsacus* and *Arctium* which were abundant along the Tucannon River indicates its importance and desirability as an emergency food.

If once established on a game land planting asparagus will survive in a mixture of weeds and grasses. This is often demonstrated by wild plants in fence rows and roadsides. Such an association furnishes desirable nesting cover. The writer has found nests in an asparagus, mixed-grass, cover type in fence rows.

Asparagus is of value to pheasants in an agricultural planting. Here its greatest value lies in the fact that the farmer harvests his crop and then a crop of cover and seed is grown for the pheasants in striking dissimilarity to small grains where, as nearly as possible, the entire crop is harvested. In such a planting cover is furnished from July through February with emergency food when needed. In a planting made on State game lands cover would be furnished for the entire year as well as emergency food.

SUMMARY

1. Requirements of emergency pheasant foods are described.
2. That asparagus meets these requirements is demonstrated.
3. On game lands plantings it has year long value as a cover plant as well as for emergency food.
4. As a farm crop its greatest value to pheasants lies in the fact that after the farmer has taken his cash crop it is allowed to grow tops which furnish cover and emergency food for pheasants.

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EFFECT OF SIMULATED GUNSHOT INJURIES ON REPRODUCTION OF GAME FARM BOBWHITES

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By means of fluoroscopy, Whitlock and Miller (1947), and Elder (1950) have shown that as much as 30 percent of some species of ducks, available from live-trapping and botulism work, are carrying lead shot in their tissues as a result of gunfire. While the migratory ability of such ducks does not appear to be affected, what can be said about their breeding capacity? Is it impaired by lead shot embedded in their tissues? Mindful of the fluctuating quail population and the ever increasing gun pressure, the question also applies to quail.

Phylogenetically, ducks and quail are remotely situated, but their fate at the hands of the hunter is similar. The more hunters afield, the more shots will be taken at quail, and the more crippling will result. As in the case of waterfowl some obviously crippled quail are not bagged. Other birds shot at extreme ranges with lighter shot are probably wounded unknowingly. In the case of some duck species, a large segment of the population in certain areas has at some time been wounded. An unknown percentage of quail may also be wounded and survive until the following breeding season. If so, does the wounding of the bird in the fall impair its later productivity? Would the shock of broken bones or perforating shot upset the normal reporduction physiology? Are non-perforating shot a source of toxicity or other physiological disturbance?

It is relatively simple to prolong egg production in confined bobwhite quail (*Colinus v. virginianus*) so it was proposed to study these questions by considering the total eggs laid and the hatchability and fertility of eggs from such quail when: (1) lead shot were manually implanted in the quail to simulate non-perforating wounds, (2) and when non-lethal punctures were performed to simulate perforating wounds.

In the conception of this experiment it was recognized that several assumptions must be allowed if the results are to have more than theoretical implications. First it is assumed that some quail are injured and not bagged. It is further assumed that some injured quail will recover, as do ducks, and live until the following breeding season. Finally it is assumed that the results from the penned populations are not absolutely invalidated when compared with the wild. The factors associated with confinement do render pen existence vastly different from wild existence, but the constancy of environmental conditions between pairs and groups at least assures the accuracy of observation. Such observations afford a clue to the questions above. Otherwise the answers may only be guessed.

[1] Journal Paper No. 523. In cooperation with the Indiana Department of Conservation supplying stock and holding facilities for this experiment.

EXPERIMENTAL PROCEDURE

Two hundred and forty-three adult, pen-reared bobwhites were used. The birds were banded and divided into four groups on November 29th, 1949, and treated in the following manner:

GROUP A. A total of 62 birds approximately evenly divided as to sex were each implanted with four No. 8 chilled shot. The shot were introduced, two under the skin of the back and two into the anterior part of the breast muscle by use of a large canula. The shot were passed through the canula, and a plunger slightly longer than the canula forced the shot from the tube before it was withdrawn from the tissue.

GROUP B. A total of 62 birds were implanted with 4 No. 8 drop shot by the same method. (Drop shot differ chemically from chilled shot in that the latter are 4-4½ percent antimony. Both kinds contain a trace of arsenic. Our thanks are due G. W. McCullough and H. C. Russell of the Federal Cartridge Corporation for this information and for their interested cooperation in supplying shot.)

GROUP C. A total of 62 birds were injured in a manner to resemble nonperforating wounds by inserting the canula into the back and breast but without implanting shot. This group also served as a control for Groups A and B to reveal any traumatic effect of the puncture alone.

GROUP D. A total of 57 birds were handled but not implanted with lead or injured for the environmental control group.

All birds were held in groups of 20 until April 5th, 1950, when the survivors were paired and placed in individual laying pens. Winter mortality in all groups averaged more than 22 percent which is the same for the D or control group. Therefore, it is not considered that the mortality in Groups A, B, and C was due to the injuries.

When laying began eggs were collected daily and marked with the pair number and the date collected. Eggs were collected for 60 days after half of the pairs began to lay. At weekly intervals the accumulated eggs were placed in an incubator. After 21 days of incubation the eggs were candled and the infertile eggs removed and recorded. The eggs were then placed in the hatcher and the unhatched eggs recorded after the hatch was over. Thus the records kept for each pair included the date of the first egg, the total number of eggs laid during the experimental period and the fertility, and hatchability of the eggs.

On September 18th, 1950, (approximately 9½ months after the shot were implanted) ten males and 9 females from Group A, and 11 males and 9 females from Group B were sacrificed and the shot recovered. Most of the shot were embedded in or between the muscles of the breast and back. In some cases where shot had been placed subcutaneously, the pellets had traveled as much as 6-8 cm. from the implantation site. The recovered shot were weighed and thus compared with similar sizes and types of unused shot.

RESULTS AND DISCUSSION

There was no significant difference between groups in the onset and progress of laying. (We are indebted to Research Statistician S. R. Miles for his statistical examination of all data

TABLE 1.—SUMMARY OF EGG PRODUCTION TO END OF EXPERIMENT, JULY 10

Group and Number of pairs	Days Laying			Eggs Laid			Av. Number Eggs Per Day Per Pair
	Av./pr.	Range	Total	Av./pr.	Range	Total	
A. 23	61	37–68	1339	39	22–53	908	.65
B. 19	58	11–68	1108	38	4–61	722	.65
C. 22	58	36–68	1294	38	9–58	834	.66
D. 20	59	16–68	1188	40	12–52	795	.67
All Groups 84	59.0	11–68	4989	38.7	4–61	3259	.65

in this experiment.) The first eggs were laid on May 4 and all pairs had begun laying by June 5. There was no evidence that the progress of lead-treated or traumatized pairs coming into production was retarded. At most points from May 4 to June 5, it was clear that for all treated groups the percentage of pairs beginning to lay equalled or surpassed the controls.

In Table 1 only a slight variation is noted between groups as to the average total eggs per pair. The differences are meaningless as well as the average number of eggs per pair per day. None of the treatments appeared to alter egg production.

Not all eggs produced were incubated. At least 130 eggs were broken or cracked when found and these were discarded. It is probable that a small number of additional eggs were consumed by the birds, or otherwise broken to pieces and escaped being discovered and counted. However, 3,129 eggs from all groups were incubated with a total average fertility of almost 94 percent (Table 2). The two groups to exceed this mark were the control Group D and the chilled shot Group A, both with 95 percent fertility. From these figures it is apparent that neither the physical presence of shot manually implanted in tissue or the presence of small amounts of arsenic in that shot had any significant effect upon fertility of eggs. Although the lower percentage of fertility in Groups B and C are not significantly different from the controls, it should be noted that the mechanical treatment of Group A was equally or more severe than in the other groups, and their slight differences are therefore not reasonably attributable to the injuries.

The hatchability results show no marked differences between groups. The eggs from the control groups had less tendency to hatch than those from Group A. Groups B and C were not significantly lower in the ability of the chicks to emerge.

The possibility that minute quantities

TABLE 2.—FERTILITY AND HATCHABILITY OF EGGS INCUBATED

Groups	Eggs Set	Percent Fertile		Percent Hatchable	
		Range	Average	Range	Average
A. 23 pair	899	73–100	95	33–98	79
B. 19 pair	697	42–100	92	47–100	75
C. 20 pair	742	50–100	93	13–94	70
D. 20 pair	791	75–100	95	33–100	76
All Groups 82 pair	3129	42–100	93.8	13–100	75

of lead or one of the other ingredients of the implanted pellets might be absorbed and cause decreased production or some degree of sterility is suggested by the reports of human lead poisoning resulting from subcutaneous absorption of lead from bullets lodged in tissues (Machle, 1940). The results of this experiment show no observable deleterious effects to egg production and egg viability of confined bobwhite quail treated in a manner to simulate gunshot wounds. When the capacity to produce normal chicks is the criterion, there is also no evidence that any systemic toxicity transmissible to offspring arose from the implanted shot. Lead absorption from the digestive tract is a different matter. Mortality from lead poisoning following ingestion of lead shot is a common occurrence among waterfowl, but in this group the relationship between lead poisoning and reproduction is obscure (Cheatum and Benson, 1945). Cole and Bachhuber (1914) reported that germ cell damage occurs in lead-poisoned fowl when the material was orally administered.

Although Fairhall and Sayers (1940) reported that metallic lead injected intraperitoneally into guinea pigs was not absorbed in significant amounts, in the present experiment there was strong evidence of weight loss of the shot while in the quail. When 64 chilled shot were weighed after 9½ months in the tissues, they averaged 3.96 milligrams lighter (significant at 1% level) than a quantity of unused shot. There was weight loss also in the used drop shot but the difference was of smaller order. However, in view of unimpaired production of quail in which the shot reposed, the weight loss of shot, even if occasioned by absorption, was of no importance.

Whereas the simulated wounds were superficial in that they were either subcutaneous or intramuscular (and therefore non-perforating in nature), it is recognized that under hunting conditions deeper punctures might well result in damage to internal organs without causing the immediate death of the bird. Non-fatal damage to gonads and other soft and highly vascular tissues, either from lodged or perforating shot, can not be ruled out as a possibility, but to study that type of wounding experimentally would be very difficult.

Because of the hypothetical nature of this experiment it is not suggested that the data positively answer any questions or apply to any other conditions. However, with reservations one may consider the implications to wild birds, which, because of their susceptibility to wounding by shot probably fill part of the test conditions studied. From the results described here, and from the abundance of wounded waterfowl on the wing, this much may be said with some surety—that birds superficially wounded can survive. In penned quail, at least, such survivors reproduce as well as uninjured birds.

SUMMARY

When non-lethal gunshot wounds were simulated in 64 pairs of game farm bobwhites, there was no evidence of impairment of productivity as compared with 20 pairs of untreated controls. The conclusion was based upon statistically insignificant differences between groups as regards onset of laying, average number of eggs laid per pair and per

pair per day, and the percentage of group fertility and hatchability.

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WHITE-TAILED DEER BAG CHECKS, GEGOKA MANAGEMENT UNIT, SUPERIOR NATIONAL FOREST[1]

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The U. S. Forest Service and the Minnesota Department of Conservation agreed in 1942 to undertake a cooperative program of game management on the Gegoka Cooperative Wildlife Management Unit in the Superior National Forest. This ten-township area is located between Ely and Lake Superior in northeastern Minnesota. It contains timber stands composed largely of aspen, birch, mature jack pine, and remnant stands of white and red pine. This habitat is typical of much of the forest in the surrounding region. Seven annual deer hunting checks have been made on the unit by state biologists and personnel of the U. S. Forest Service from 1942 to 1949; no check was made in 1945. Equipment for the erection and maintenance of checking stations was furnished by the Forest Service.

[1] A contribution from Pittman-Robertson Project 11-R, Minnesota Department of Conservation, Division of Game and Fish.

CHECKING METHODS EMPLOYED

Because of limited personnel and gasoline restrictions during the war years, field work was limited to a hunting camp check in a single township during the hunting seasons of 1942, 1943, and 1944. The following disadvantages in the hunting camp check became apparent. Successful hunters could leave the first day without being checked; all hunters had to be checked daily; it was not possible to determine general hunting pressure or success; the hunting take on the township could not be projected over the entire ten-township unit with accuracy; and finally the deer take on the town-

ship was so small that sex and age ratio data were of doubtful value.

In 1946, maps of the management unit were posted in hotels, resorts, and camps in and adjacent to the unit, with instructions for hunters to plot their kill and to indicate its sex and age. The disadvantage of method was that it was not possible to familiarize all hunters with the method. By the fourth day of the 1946 season only about 50 per cent of the hunters had become familiar with the checking system. In addition, hunters were reticent about giving information because of fear of law enforcement and revelation of choice hunting territory. Also, final success figures were based on estimates since the number of hunters who failed to register remained unknown.

In 1947, 1948, and 1949, a checking station was maintained at each of the four exits from the area. Personnel at these stations checked hunters leaving the area after they had completed hunting for the season. Information recorded included the number of hunters in the party, resident county of each hunter, sex, age, and antler beam measurements of deer killed, and deer weights whenever possible. This checking station method of tallying hunters proved to be the best of the three systems tried.

HUNTING PRESSURE

During the first three years of the check, 1942-1944, all work was concentrated in a single township. Because of several good roads and two resorts located in the township, the resulting figures on hunting pressure are probably higher than that in other townships in the unit. As shown in Table 1, hunting pressure decreased during the last three years of the checks. On opening day in 1947, 1948, and 1949, there was less than one hunter per square mile in the area, and because many hunters work in parties, there were some square miles that were not hunted at all. Car counts made on opening mornings in 1947 and 1948 showed only about one hunter per mile on each side of the road. With the decrease in hunting pressure there was also a decrease in hunting party size. For example, in 1944 there were 3.8 hunters per party; in 1948, 2.9; and in 1949, 2.6. During the last three days of a nine-day season, there was a marked reduction in hunting pressure from that experienced during the first three days.

TABLE 1.—DEER HUNTING PRESSURE AND SUCCESS RATIOS IN THE GEGOKA WILDLIFE MANAGEMENT UNIT, MINNESOTA

Year	No. of Hunters	Hunters per square mile	Deer Killed	Per cent success** A	Per cent success** B	Days of Season
1942*.....	181	5.5	124	68.5		11
1943*.....	194	5.9	54	37.2		5
1944*.....	157	4.8	67	42.7		9
1946.....	808	2.2	193	71.2		9
1947.....	1,050	2.9	292		27.8	9
1948.....	850	2.4	166	35***	19.5	9
1949.....	693	1.9	182	45***	26.3	5

* Based on one sample township only.
** Column A based on hunters who hunted only in the Gegoka Unit; Column B based on all hunters in area regardless of success elsewhere.
*** Estimation based on local gun club survey of 728 hunters.

HUNTER SUCCESS AND DEER KILL PER UNIT AREA

Success ratios for all years can not be compared directly because of the various methods used in checking hunters. Success figures (Table 1) for 1942 through 1946, however, are accurate since they were based only on known kills and can be compared with each other. The success figures for 1942 and 1946 are significant in that they indicate high deer populations followed by severe winters which were followed by poor hunting success in 1943 and 1948. The area experienced severe winters in 1942-43 and 1947-48, and the herd suffered considerable losses.

The percentage of successful hunters from 1947 on cannot be compared with the higher statewide ratio because all hunters were tallied as they left the Gegoka Unit whether they hunted one hour or the entire season. Hunters who failed to get a deer in the Gegoka area may have succeeded in bagging a deer elsewhere. The fact that they hunted in the area was recorded; whether they were successful elsewhere is not known. The only value of the per cent ratio, therefore, from 1947 on, is that it serves as a ratio for the area itself and can be compared in that light. It is significant that the success ratio dropped in 1948 as it did in 1943, after a severe winter. A surprisingly good season was experienced in 1949 when the success ratio was equal to that of 1947, and achieved in only five days. This was in spite of popular opinion that the season should have been closed.

An increase in success in the general Ely area from 36.7 per cent in 1948 to 48 per cent in 1949 was shown in a big game survey conducted by the local Ely Rod and Gun Club. A similar trend is evident in the Gegoka Unit where the ratio increased from 19.5 to 26.3 for the same years. These ratios are based on all hunters who used the Gegoka Unit whether they hunted all season or but one hour. There is an indication then that the actual success ratio for those hunters who did all their hunting in the Gegoka Unit during the season was about 35 per cent in 1948 and 45 per cent in 1949.

Hunter success on a statewide basis shows a trend over the years similar to that experienced in the Gegoka Unit. For example, the 1942 deer kill was the largest recorded in the northern deer range up to that date. The resulting estimated statewide kill was also the greatest recorded, a total of 77,000 animals. This kill was only exceeded in 1946 when most of the state was open to deer hunting and an estimated 94,500 deer were taken. The tremendous drop in the 1943 Gegoka Unit kill was due to a short season, the heavy kill in 1942, and the severe winter of 1942-43. Since 1942 the hunting take has had little effect in reducing the deer population. (Table 2.) State and U. S. Forest Service

TABLE 2.—MINNESOTA DEER KILL PER SQUARE MILE FOR VARIOUS AREAS AND YEARS

Year	Superior National Forest	Gegoka sample Township only	Entire Gegoka Unit
1934....	1.5		
1936....	2.0		
1937....	1.7		
1938....			
1940....	2.6		
1942....		6.3	
1943....		1.8	
1944....		2.4	
1946....		3.9	
1947....			0.8
1948....			0.6
1949....			0.6

figures (1948) showed an average of about eight animals per square mile in the northern deer range; thus a take of less than one deer per square mile is not even harvesting the surplus numbers produced each year. The population in the Superior National Forest in 1939, as calculated from census area drives conducted by Civilian Conservation Corps crews, was 14 deer per square mile (Fredine, 1940). Deer browse surveys and winter yard studies conducted in 1949 indicate that the deer range is deteriorating due to heavy overbrowse prior to 1947, and to natural plant succession. Much of the brush and second growth aspen and birch which covered the area following the logging and fires early in the century, is being replaced by balsam fir, white and black spruce, and jack pine. The climax forest for the area is coniferous, not deciduous, and therefore, will not provide the optimum conditions for a deer herd.

WEATHER CONDITIONS

Minnesota deer seasons generally open about the third week in November. On four out of the seven opening days, 1942-1949, there was snow on the ground in the Gegoka Unit. However, the importance of snow for visibility and tracking can be questioned when it is realized that complaints in 1943, 1947, and 1948, were of too much snow and that 1949, with rain but no snow on opening day and generally poor conditions during most of the five-day season, resulted in the best hunters' success since 1946. Hunting conditions for the seven seasons were rated as generally poor every year except 1946. It appears that weather in general has been highly overrated as a factor governing the kill in the management unit.

SEX RATIOS AND AGE CLASSES

The sex ratio of 1,334 deer killed in the Gegoka Unit (Table 3) over a period of 8 years, 130 males : 100 females, is comparable with the statewide sex ratio of 138 males : 100 females, over the same period. The equal sex ratio among fawns taken in the Gegoka area indicates either a differential sex mortality in adults or the tendency for more bucks to be shot during a hunting season.

MISCELLANEOUS DATA, GEGOKA UNIT AND SUPERIOR NATIONAL FOREST

Since 1936, a total of 1,706 deer has been weighed on the Superior National Forest. Dressed weights of these deer averaged 161 pounds for 925 adult bucks, 121 pounds for 641 adult does, and 68 pounds for 140 fawns.

Generally, most deer are shot the first day of the season. In 1944, 30 per cent of all deer taken on the Gegoka Unit were shot the first day and by the end of the fourth day of a nine-day season, 85 per cent of the total kill had been tallied. This general time distribution of kill prevailed also from 1946 to 1949.

In 1942, 90 per cent of 112 kills was made three-fourths of a mile or less from a road or trail. Most hunters never go farther than one-half mile from a road or trail.

Liver fluke (*Fascioloides magna*) is apparently not common in deer killed in the Superior National Forest. Of 87 livers checked in 1948, only one contained flukes.

TABLE 3.—SEX AND AGE RATIOS OF DEER KILLED ON THE GEGOKA UNIT

Year	Total No. Deer	All deer males per 100 fem.	No. of adult males	No. of adult fem.	Adult males per 100 adult fem.	No. of Fawns	Per cent Fawns	No. male Fawns	No. fem. Fawns	Male Fawns per 100 fem.
1942	112	120	51	42	121	19	16.9	10	9	111
1943	40	208	23	12	192	5	12.5	4	1	400
1944	59	136	30	23	130	6	10.2	4	2	200
1946	425	120	180	146	123	99	23.3	52	47	111
1947	280	139	137	80	171	63	23.3	26	37	69
1948	210	113	92	76	121	42	19.6	19	23	82
1949	208	157	106	59	180	43	20.7	21	22	95
TOTALS: 1,334			619	438		277		136	141	
AVERAGES:		130			141		20.8			96

SUMMARY

1. Seven deer checks have been made on the Gegoka Wildlife Management Unit since 1942. From 1942 through 1944, checks were conducted on a sample township. In 1946, results were obtained by having hunters voluntarily plot kills on maps posted at accessible points. From 1947 through 1949, checking stations have been maintained at each of the four exits from the area. The checking station method proved the most accurate and practical.

2. Hunting pressure was generally light in the Gegoka Unit and surrounding area. Only one to two hunters per square mile, if all hunters tallied were utilizing the area at the same time, were hunting the area in 1947, 1948, 1949.

3. The kill of deer on the unit has been light since 1942. Since 1947 less than one deer per section has been harvested. Because it is estimated that the area supports a population of about eight per square mile, a harvest of one deer per section does not even remove the surplus.

4. The sex ratio of 1,334 deer examined during the study was 130 males : 100 females. The sex ratio of 277 fawns was 96 males : 100 females. the sex ratio of 1,057 adult deer was 141 males : 100 females.

5. In view of the low hunting pressure and take on the Superior National Forest, it is biologically sound to remove an annual harvest of deer from the area until range conditions give reasons to do otherwise.

6. In 1944, 30 per cent of 59 deer taken were shot the first day of the season and by the end of the fourth day of the nine-day season 85 per cent of the total kill had been bagged.

7. In 1942, 90 per cent of 112 deer was shot three-fourths of a mile or less from a road or trail. Few hunters ventured farther than one-half mile from a road or trail.

8. Only one deer liver of 87 examined in 1948 contained flukes, *Fascioloides magna*.

9. During the 1949 deer season controversy, the Gegoka Unit data proved valuable in showing that hunters could not have reduced the deer population to the danger point during previous seasons. Hunters experienced the best hunting during the 1949 five-day season since 1946, despite popular preseason prophecies to the contrary.

10. The data for the Gegoka Wildlife

Management Unit are especially valuable because the unit is the only naturally wild area in the state in which the hunting pressure and kill are known per unit area.

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THE IMPORT OF CATASTROPHIC MORTALITIES FOR MARINE FISHERIES ALONG THE TEXAS COAST

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INTRODUCTION

In spite of the oft-stated aims of fishery biology and conservation there is no adequate information concerning any species of fish, shrimp or crab along the Gulf Coast of the United States upon which to base any law or restrictive measure purporting to lead to conservation. Dozens or even hundreds of laws exist, nevertheless, in the various states. Some of these are based upon the recommendations of biologists on the basis of some facts and calculated guesses concerning others. Other laws were passed upon the recommendations and urgings of people, biologists or not, who were simply deluded and did not understand the complexities of marine fisheries biology or marine ecology. This situation exists because of our relative ignorance of marine biology of the Gulf Coast. It is theoretically possible to ascertain the proper facts, but the necessary programs will entail a much larger expenditure than any heretofore contemplated. In fact this situation holds over practically the whole world and there is doubt about how much marine fisheries anywhere have been benefitted, controlled or conserved by any restrictive measure (Burkenroad, 1948 and 1951).

The chief facts needed for adequate control are: knowledge of the amount of the population masses, the growth rates of the species involved and their natural rate of mortality. All of these factors are variable and quite difficult to determine. They are also interdependent and will probably all have to be determined together before they will have much meaning. If a conservation program is to be carried on continuously, these factors will also have to be watched continuously by trained biologists along various parts of the coast, just as trained meteorologists must continue to watch the weather. At the present rate of investigation along the Gulf Coast these facts will never be determined for even one species, let alone the total Gulf fisheries.

In addition to the above, which is the case for most coasts of the world,

the Texas Coast presents a unique situation of great importance to fisheries management and conservation locally in that it is visited at rather frequent intervals by catastrophic mass mortalities of marine organisms coming from purely natural causes. In this paper the writer proposes to discuss the import of these mass mortalities for conservation and utilization of Texas marine fisheries.

CAUSES AND FREQUENCIES OF CATASTROPHIC MORTALITY

A. Hypersalinity of the Laguna Madre.

The southernmost lagoon of the Texas Coast is some 115 miles long and about 4 miles wide. Large parts of the area are shallow and there is no river or stream other than certain intermittently running arroyos flowing into the area. The only drainage into this body of water is sheet or laminar drainage from the inland coastal prairie and the area lies within a semi-arid climatic belt. In its natural state the Laguna was practically blocked off at the northern end by a sand bar and separated in the middle by another extensive sand flat. Therefore, the salinity in this body of water and a connecting branch, Baffin Bay, is always higher than sea water and in certain years rises to amazing heights. The monthly average salinity is over 50 parts per thousand. Salinities of 80 parts per thousand are not uncommon and salinities of above 100 have been taken in this area many times. For comparison it should be remembered that the average salinity of undiluted sea water ranges from 33 to 37 parts per thousand in the various oceans of the world. In spite of the fact that the region is hypersaline it supports a large fish population and for the past 20 years or so has produced approximately 50 per cent of the fin-fishes taken commercially on the Texas Coast.

A description of the Laguna Madre and its hydrography may be found in Hedgpeth (1947) and Collier and Hedgpeth (1950). When the salinities of the Laguna rise to above 80 parts per thousand the fishes begin to die and some mortality occurs every summer. During some years the salinities rise to such heights that practically every living thing within the area is killed. The distances are too great for the fishes to escape and in the northern Laguna at least they were blocked off by shallow areas which were hotter and saltier than the deeper water from which they came. The last complete kill came in the summer of 1937. It was said by old residents that this was the most drastic kill in the area since 1914. However, heavy kills were reported to occur about once every 10 years. The numbers of fishes killed at times of extreme hypersalinity in this area are unknown but it certainly runs into millions of pounds. It probably ranges in the neighborhood of 10,000,000 pounds of fishes.

In 1948 the intracoastal canal was cut through the length of the Laguna Madre. This affords some egress through deeper waters to the Gulf and possibly it will afford some water circulation which will prevent or tend to prevent future recurrences of fatal hypersalinities. Time will tell that story.

B. The "Red Tide" or dinoflagellate bloom.

In the summer of 1935 a very heavy mortality of marine fishes and other animals occurred in the Gulf of Mexico

and extended for a distance of 250 miles from the Rio Grande northward. A few fishes were killed in the lower bays but practically all of the mortality was confined to the Gulf. The amount of destruction was undetermined, but it was certainly enormous and ran into many million pounds. Since that time there was one other occurrence of this phenomenon in the fall of 1948. It occurred along the southern tip of the coast and was more localized. The cause of this terrific mortality was unknown and undetermined in 1935, but comparison with the huge similar outbreak in Florida during 1946 and 1947 makes it practically certain that the causes were the same. The Florida outbreak was found to be caused by a vast dinoflagellate bloom (Gunter, Smith and Williams, 1947). A case of recurrent localized mortality associated with dinoflagellate bloom along Galveston Island has been reported by Connell and Cross (1950).

The dinoflagellates are phytoplanktonic organisms which reproduce in excessive numbers under certain conditions, most of which are unknown. However, it is recognized that a higher than usual concentration of nitrates and phosphates must be present in the water masses involved. These dinoflagellates secrete a poisonous substance which is liberated directly into the water or released upon breakdown of the cells. It kills fishes and other marine organisms and causes respiratory difficulties to men and animals along the beach when the surf is heavy. It seems to be borne into the air not as a gas but in suspended water droplets from the surf. So far as present information goes, we can only say that greater and lesser occurrences of this phenomenon have taken place on the Texas Coast twice in 15 years.

C. Mortalities caused by cold waves.

The cold polar fronts push as far south at the longitude of Texas as at any place on earth. These are the well-known Texas northers of fact and story. Occasionally they are strong enough to cross the Gulf of Mexico and the Isthmus of Tehuantepec down to Nicaragua on the west side.

Texas has approximately 3,500 square miles of bay waters. These are the home of shrimp, blue crabs, oysters and several species of fishes. The waters are all shallow, the average offshore depth being 6 to 8 feet. The bays are connected with the Gulf of Mexico by relatively narrow passes, there being only five of any size along the 360 miles of shoreline. Due to these physiographic features and the extremely rapid onset of the northers, accompanied by sharp drops in temperature, relatively frequent mortalities of marine life are caused by cold waves. Gunter (1941, 1945) and Gunter and Hildebrand (1951) have recorded instances.

Since and including 1940 there have been three cases of light mortality of marine organisms caused by cold waves (1941, 1948 and 1949), one case of heavy mortality (1947) and two which caused such enormous damage that they may be called catastrophic. These occurred in 1940 and 1951.

DISCUSSION

Descriptions of the cases of mortality giving details of ecological and biological importance have been given in the papers listed above and in certain

others cited in them. A discussion of the paleontological significance of catastrophic mortalities of marine organisms in the northern Gulf of Mexico was given by Gunter (1947a). For the present discussion we are interested only in the frequency of these natural mass die-offs and the amount of destruction caused.

Records of happenings along the Texas Coast were not well-kept or organized before the Game, Fish and Oyster Commission added a Marine Biologist to the staff in 1936 and we can only be on firm ground by starting with the dinoflagellate bloom of 1935. Taking all mass mortalities of marine organisms together and the numbers of their occurrence, there have been nine along the Texas Coast in the seventeen years since 1935. Four of these were light. One was caused by dinoflagellate bloom in 1948 and three were caused by cold in 1941, 1948 and 1949.

In 1947 there was a heavy mortality caused by cold. Severe or catastrophic mortalities were caused by plankton bloom in 1935, hypersalinity of the Laguna Madre in 1937 and cold waves in 1940 to 1951. The amount of mortality is very difficult to determine. In 1935 fishes washed up on the beaches in large numbers for 200 miles. The amount killed may have ranged from 10 to 100 million pounds or even more. The fishes killed in the Laguna in 1937 may have ranged from 5 to 25 million pounds. Biologists of the Game, Fish and Oyster Commission estimated that 60 to 90 million pounds of fishes were killed by the 1951 cold wave, and they firmly believe this estimate is on the conservative side. In my estimation the 1940 cold wave caused even more damage.

The observed mass mortalities came 9 times in 17 years, and four were catastrophic. Taking all things into consideration it appears conservative to estimate the total kill of fishes alone at between 200 and 250 million pounds.

Marine products reports for the State of Texas were begun in the fiscal year 1936-37. Table 1 shows the total commercial fish catch for all available years since that time. The red snapper catch is not included because it comes from deep offshore waters, beyond influence of the factors under discussion. Shrimp, crab and oyster production are not included. Of the total fish production, exclusive of red snapper, approximately 90 per cent comes from the bays. Of the mass mortalities discussed here, only the hard cold waves affect the whole bay area. Significantly, sizeable drops in commercial production appear only after hard cold waves. For the three years prior to the 1940 freeze the total fish production was 13,189,000 pounds. For the freeze year and the two following it was 7,195,000 pounds, a fall of 46 per cent. Recovery did not come until 1943. Similarly, in the three years preceding the 1947 freeze, when compared to the 1947 freeze year and the two following years (which included two light kills), the production was 11,825,000 and 6,343,000 pounds, respectively, a decline of 47 per cent. Recovery was obscured in 1949-50 by complete closure of the Laguna Madre to netting, but apparently the catch rose along the remainder of the coast. A big drop will come again in the fiscal year 1950-51 following the 1951 catastrophe.

In short there will have been a maximum of 5 years out of 12 since 1939-40 fiscal years to and including

1950-51, when the population of fishes along the Texas Coast was not diminished from the effects of hard cold waves. And, if we may interpolate from the past, the years 1951-52 and 1952-53 will show effects, so that actually there will be five good years in fourteen.

TABLE 1.—THE FISH PRODUCTION OF THE TEXAS COAST, EXCLUSIVE OF RED SNAPPER AND MENHADEN, FOR THE VARIOUS FISCAL YEARS BEGINNING SEPTEMBER 1, AS REPORTED BY THE GAME, FISH AND OYSTER COMMISSION. FIGURES ARE IN POUNDS

Year	Pounds	Year	Pounds
1936–37	4,145,000	1943–44	4,203,000
1937–38	5,125,000	1944–45	4,250,000
1938–39	3,919,000	1945–46	3,472,000
1939–40	2,133,000	1946–47	2,101,000
1940–41	2,079,000	1947–48	1,895,000
1941–42	2,983,000	1948–49	2,346,000
1942–43	3,767,000	1949–50	2,005,954

Declines in the sports fishermen's catches also follow in freeze years, as is well known. How much they catch is unknown, but it has been estimated by former officials of the Game, Fish and Oyster Commission at equal to or greater than the commercial catch.

Looked at another way, if the catch is roughly proportional to the fishable population within the limits of variation of the latter on this coast, then from freezes alone the fishable population was cut or will have been cut about 50 per cent in nine years out of fourteen between 1940 and 1953. This conclusion cannot be rigidly derived from the information at hand, however, for with declining catch the commercial fisherman is less inclined to fish. This factor is somewhat offset by a quick increase in price following heavy cold kills, which usually amounts to around one-third. In 1951 the price jumped from around 25¢ to 35¢ per pound. There is no information showing how much these factors offset one another, so the exact situation is unknown. Nevertheless, if the estimates of the amount of kill in 1951 (60,000,000 pounds) is roughly correct and the reduction in total population of fishes is roughly comparable to the reduction in commercial fishes, then the population of fishes in Texas bays must run between 150 and 200 million pounds in good years, of which about 5 per cent or less is caught by commercial and sports fishermen. Possibly these estimates are wide of the mark. Nevertheless, if the freezes of 1940, '41, '47, '48, '49 and '51 killed only 100,000,000 pounds of fish, then the figure is 3 times the amount taken commercially between 1940 and 1951 from Texas bay waters. Actually the kill was probably larger. Not all fish killed are commercial or sports fish. It was estimated that at least 8,000,000 pounds of "good" fish were killed in 1951. This is roughly 10 per cent of the total kill. The 1940 and 1947 episodes were comparable and it can be said that at least 25 to 30 million pounds were killed by cold between 1940 and 1951. This about equals the commercial catch during that time and seems to be a conservative estimate.

Nevertheless, there seems to be some error in the estimates, for the estimated annual commercial and sports catch of 4 to 8 million pounds does not reduce the catch, while the estimated cold kill of 8,000,000 pounds does reduce it in following years. Either the sports fishermen's take, the unknown factor in catch, is less then estimated or the cold kill of "good" fish is much higher than suspected. This anomaly highlights the difficulty of estimating total or

commercial fishery stocks of the Texas bays on the basis of present information.

Figures on a yearly basis include four and a half to five months unaffected by the freeze in the "freeze year" statistics, for the fiscal year of the State of Texas begins September 1 and the freezes usually come in January. The total decline in commercial fish production for the freeze years and the two following years has been shown to be around 50 per cent. This is only an average, however, and for the months immediately following the freeze the decline is about 70 per cent.

In any case the rate of replacement is fast. Since the effects of freezes extend far down the Mexican Coast, and most damage seems to be done in the Laguna Madre, it is thought that immigration of fishes from other areas is negligible. It seems more likely that growth of the smaller, unfished population leads to reestablishment of the former equilibrium in about three years. Apparently, the smaller fishes are not as susceptible to cold damage as their large congeners, as has been noted by various workers (Gunther, 1947b), and these replace the fishable stock rather quickly.

Nevertheless, the peak or normal equilibrium of fishable stock does not long remain before freezes remove a large part of it. The large number of edible fish destroyed by catastrophic freezes is an observed fact and is not theoretical. There is evidently a build-up of the commercial fishery stock between the hard freeze years, indicating that the combined sports and commercial fishery is not very intense. This stock or surplus is rigidly protected and thus underfished until such time as the next hard freeze removes a large part of it.

In spite of this situation there are many restrictive laws concerning commercial fishing in Texas bays. The Laguna Madre in particular suffers extensive fish loss from the freezes as well as from hypersalinity. Yet all netting is prohibited in the lagoon, and it is actively patrolled by the Game, Fish and Oyster Commission at considerable expense. As one official of the Game, Fish and Oyster Commission said to me recently, "We spent a lot of money keeping people from getting the fish out of the Laguna so the freeze could get them." That succinct statement applies to the whole bay region of the Texas Coast.

CONCLUSION

The Texas Coast is subject to natural catastrophes, chiefly hard freezes, which come every few years and kill more fish than are taken out of the bay waters by man. Restrictive measures merely conserve the population until such time as a large part of it is destroyed by hard cold waves and other catastrophes. Such measures are non-conservational and costly and are against the public interest. Restrictive measures relating to fishing in the bay waters of Texas should be abolished.

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EVIDENCE OF THE AGE OF BEAVER PONDS

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Beaver through dam building and tree cutting activities produce changes in habitat some of which are persistent. The beaver meadow is an example of relatively stable conditions resulting from repeated beaver occupancy. The writer as well as numerous other investigators (Davis 1907, Warren 1932, Ives 1942, Robb 1942, and others) has observed this reoccupation of old ponds. The time interval between abandonment and subsequent reoccupation depends chiefly on food conditions and varies from a few years to 20 years or more. This alternation of use and disuse of certain pond-sites is the result of vegetational changes both within the boundaries of the former flowage and on the surrounding upland. When aspen or other preferred food species become abundant about the abandoned pond-site, beaver again move back into the area. After the food supply is exhausted the beaver move elsewhere.

In 1948 the writer undertook an ecological study to determine the relationship existing between beaver and forest vegetation on the headwater streams of the East Branch of the Ontonagon River in Iron and Houghton Counties, Michigan. In this project, it was necessary to determine the age of beaver ponds and the periods of their occupancy. Certain techniques were developed for this purpose and are presented in this paper.

[1] A portion of an ecological study of beaver to be submitted as a partial requirement for the doctorate. Appreciation is expressed to Professor S. A. Graham under whose direction the investigation was made and to Professors E. C. O'Roke and W. W. Chase for suggestions in the preparation of the manuscript.

METHODS

Vegetation within the beaver's zone of influence is subject to changes in age and species composition as well as marked changes in growing conditions. The altered conditions may favor some species and suppress or eliminate others. Woody vegetation in the annual growth rings provides a record of the occurrence of favorable or unfavorable conditions. Therefore a study of the rings of trees and shrubs growing within the zone of beaver influence will reveal the sequence of changes that have taken place.

The width, appearance, and number of annual rings of a tree proved to be the most important and reliable source of field evidence indicating the age of beaver ponds. Other field evidence such as the condition of the dam, the appearance or condition and silting in of the pond area, and the presence or absence of certain plant species all proved to be unreliable criteria of age.

For the study of annual growth rings of woody vegetation, two types of samples were used: cross sections and increment cores. A 30-inch Swedish type bow saw proved to be ideal for collecting cross sections. The saw was light and easily managed by one person. Increment cores were collected with a 10-inch increment borer.

Detailed information was obtained and recorded concerning conditions under which each sample was collected. A form for this purpose was prepared on 5x8 cards, a convenient size for field use. By either filling in blanks or checking certain information incorporated into the form, the following data were recorded with a minimum of writing: location of the pond and identity of the sample; type of sample and the kind of evidence collected; the species with its size, vigor, and location (on dam, cutting area, edge of pond, former pond area, etc.) of woody plant sampled; site conditions (soil and moisture). The results of sample analysis were later recorded on the form. Cross sections were marked on both sides with a lumber crayon to insure certain identification. Increment cores were placed in numbered tubes. Large bore soda straws, plugged with cotton, made excellent field containers for the cores.

Data collected from cross sections analyzed in the field with a hand lens may be subject to error due to difficulty in distinguishing rings. Therefore it is best if samples are analyzed in the laboratory. However, if ring counts are made in the field, they should be done immediately after the section has been removed from the tree. Then the rings are most distinct. By making a check count along two radii, errors due to miscounting can be reduced. Smoothing the sawed surface of the sample with a sharp knife as indicated in Fig. 1 will aid in making the rings more distinct.

HEALING OF BEAVER SCARS IN CROSS SECTION
OPEN SCAR
OPEN SEAM SCAR
CLOSED SCAR WITH VERTICAL SEAM
A-B POSITION OF SMOOTHING CUT

FIG. 1. Schematic drawings of the three main stages in the healing over of beaver cutting scars by callus growth. The drawings are based on cross sections cut from aspen.

When cross sections are analyzed in the laboratory, using a low power dissecting microscope, errors due to mis-

counting are negligible. The sections should be permitted to dry several days, then polished. For this operation either a small disk or hand sander is quite satisfactory. By treating the sanded surface of the cross section with a light oil the rings can be made more prominent.

Increment cores were used instead of cross sections when observations on the growth of conifers were made, but they were not satisfactory for hardwood species because of the difficulty in distinguishing the rings. This difficulty was especially true of aspen. To avoid damage to future wood products, all borings were made below stump height.

As with cross sections, the increment cores were analyzed in the laboratory. In studying ring patterns, plotting the annual radial growth on graph paper facilitated analysis. A detachable stage micrometer mounted on a block of wood was used to measure ring widths for plotting. (See Fig. 2). A 10-inch piece of moulding grooved to hold a core was attached to the left arm of the slide carrier. For ring measuring, the core in its holder was placed under a low power dissecting microscope that had a fixed pointer in the center of its field. Micrometer readings were noted for each ring as it passed the pointer. The difference between two readings equals the annual ring width. A vernier on the micrometer permitted readings to be made to the nearest 1/10 mm. Considerable care had to be exercised in measuring, so that the true distance, i.e., the perpendicular distance between rings, was recorded. Measurements were taken in a direction parallel to the wood rays to insure accuracy. The core holder was pivoted at point of attachment to the micrometer so that any necessary changes in alignment of the core during measuring could be made. By smoothing and moistening the upper surface of the core, rings were made more prominent.

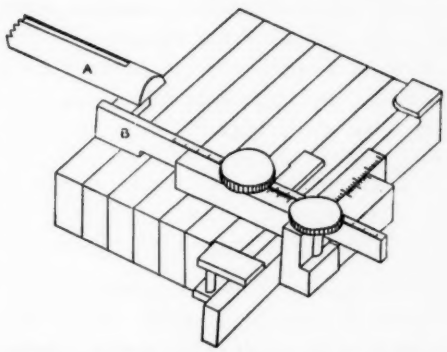

FIG. 2. Schematic drawing of a stage micrometer modified for measuring the annual rings of an increment core. A grooved piece of moulding (A) attached to the slide carrier (B) holds the core in position for measuring. The core in its holder is then placed under a low power dissecting microscope with a fixed pointer in the center of its field. Micrometer readings are noted for each ring as it passes the pointer. The core holder is pivoted at point of attachment to the micrometer to permit any necessary changes in alignment of the core during measuring.

When interpreting the evidence obtained from woody materials, it is necessary to add one year to the indicated age. This must be done because beaver activities producing this evidence usually occur in late summer or fall after the current annual growth has been completed. For example, if in a sample collected in 1950 there have been 15 rings laid down since a beaver produced effect became evident, the activity causing this effect occurred 16 years ago, or in 1934.

In addition to the evidence obtainable from woody plants, other sources of evidence such as, General Land Office Survey Notes, timber cruise reports,

stream surveys made in connection with biological inventories, aerial photographs and interviews with local residents, provided important data supplemental to the findings based on field observations. In very few instances will all the following sources of evidence apply to any single pond. However, every piece of available evidence should be obtained so that each will serve as a check on the others.

EVIDENCE OBTAINABLE FROM THE ANALYSIS OF ANNUAL GROWTH RINGS OF WOODY VEGETATION

Evidence from Callus Growth: Beaver frequently abandon work on a tree, leaving it partially cut. If the cutting scar does not girdle the tree or is not so deep that the tree is weakened and broken by wind, callus growth will in time heal over the wound. The year when the tree was injured may be determined by counting the annual rings in the callus growth.

Since these partially cut trees are present in almost any area logged by beaver, the resulting callus growth provides positive evidence of when cutting operations occurred. Partially cut trees occur very frequently near the edges of cutting areas. Species less preferred for food than aspen, such as maple, white and yellow birch, cherry and occasionally conifers, are especially likely to bear cutting scars, particularly when situated near the pond's edge. The schematic drawings in Fig. 1, based on cross sections cut from beaver scarred aspen, illustrate the 3 main stages in healing over of the scar by callus growth. The open scar is the most obvious and most frequently encountered of the three. Callus growth with open or closed vertical seams often covers injury caused by beaver. However, similarly appearing scars may be the result of other injuries caused by ground fires, power equipment, or decay. It is not difficult to find clues which will prove whether or not beaver are responsible. Such clues are: the presence of an undercut or tooth marks beneath the callus growth, the size and height of the scar, and the position of the scar, where the tree is located immediately adjacent to the stump of a beaver cutting.

For counting the rings of callus growth, an entire cross section of the scar and accompanying callus growth was cut from the tree. With larger trees a wedge shaped section, including the center if possible, was removed. Frequently during the drying of scar sections, the callus growth separated from the scar and a crack formed extending back into the area of normal growth. This crack usually separates the growth rings formed before the injury from those laid down after injury. The separation is an aid, as it fixes the year of injury, and is most useful when the area adjacent to the scar is discolored due to rot.

Evidence from Sprout Growth: Beaver fell some trees during the spring and summer for food. With the coming of fall, the tempo of this activity is greatly increased as the beaver prepare for winter. Cutting of aspen at this season insures a maximum production of root sprouts the following spring (Zehngraff 1946). Thus, the year beaver were active in a cutting area can be determined from the age of the resulting sprout growth.

Root sprout or sucker stands are

readily identified by their uniform appearance, close spacing and the scattering of a few larger and older trees throughout the younger stand. The presence of old beaver-cuttings, proximity to an old beaver pond, and a definite boundary to the stand are distinguishing features of sucker stands developing in old beaver-cutting areas. Where there is an absence of beaver sign in sprout stands of small area adjacent to water, the possibility of fire or logging must be ruled out before considering the stand as originating from beaver-cutting activities.

The age of sprout stands was determined from cross-section disks cut from several dominant trees. These sections were cut below a height of 18 inches to insure accurate determination of age.

Stump sprouts are more prone to heart rot than are root sprouts and therefore do not always provide satisfactory cross sections. This condition was encountered more frequently in aspen than in other hardwoods, such as

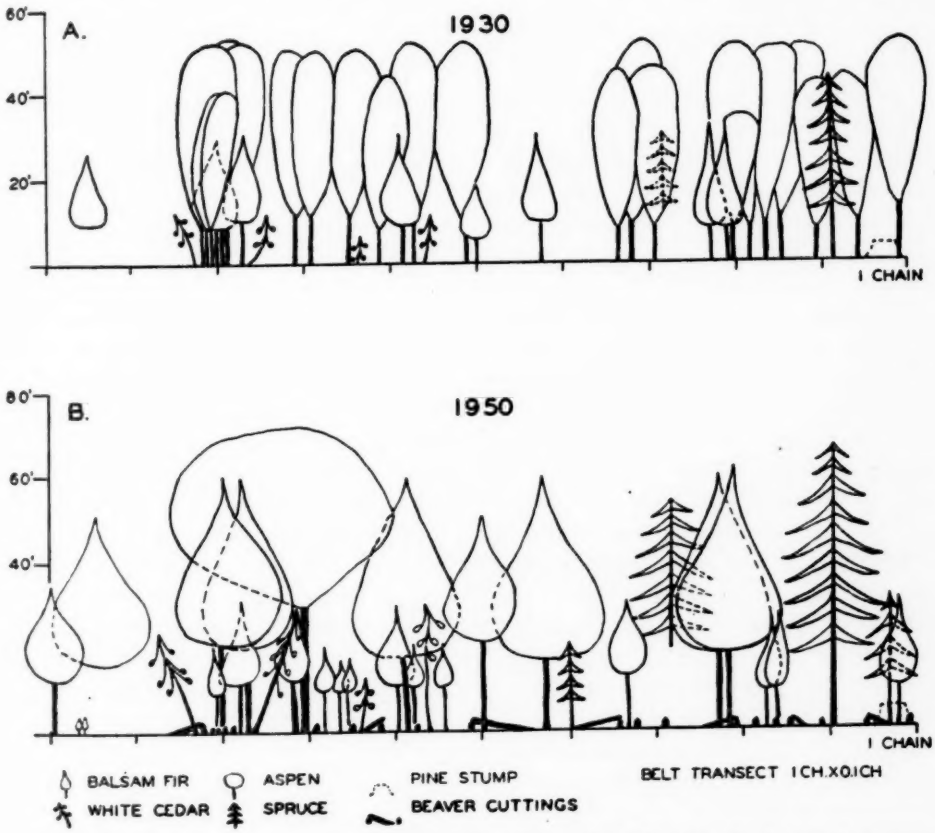

FIG. 3. Profiles of a belt transect illustrating the changes brought about by beaver in spruce-fir stand. The belt transect is 1/100 of an acre (1 ch. x 0.1 ch.). Trees not occurring on the transect but whose crowns extend over the transect are shown without trunks. Profile A. A reconstruction of the appearance of the plot in 1930 prior to the removal of the aspen overstory. Profile B. The appearance of the transect in the summer of 1950.

cherry, white and yellow birch, and alder.

Evidence from Conifers Released by Beaver Cuttings: Many spruce-fir stands that develop on old burns frequently possess aspen overstories. The aspen and the conifers may be the same age, both having seeded in the burn together. However, the aspen by virtue of its more rapid growth, soon overtops and suppresses the slower growing conifers. This leads to the formation of a two-storied stand.

When stands with aspen overstories occur in the immediate vicinity of water, beaver may visit the stand and cut out the aspen. In the parlance of the forester, the beaver have made a release cutting for the conifers. In Fig. 3 sample plot profiles from a spruce-fir stand illustrate the above condition. Profile A reconstructs the appearance of the plot in 1930 prior to the removal of the aspen overstory by beaver. Appearance of the plot in the summer of 1950 is shown by profile B.

The removal of this aspen overstory has a marked effect on the growth rate of the understory conifers. (See Fig. 4). The year following release is readily distinguished by a substantial increase in the annual radial growth of the conifers. The determination of the year of release for a stand should be based on data gathered from a number of trees. Several cores for comparison should be collected from those trees not affected by the removal of the aspen overstory in order to avoid possible misinterpretation.

Balsam fir responds very quickly to the release and is a particularly desirable species to show this effect. The distribution of aspen stumps can be used as a guide in selecting the trees to bore. The release effect will be more prominent in those trees that have developed under former clumps of aspen.

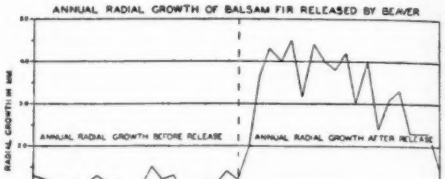
ANNUAL RADIAL GROWTH OF BALSAM FIR RELEASED BY BEAVER
ANNUAL RADIAL GROWTH BEFORE RELEASE
ANNUAL RADIAL GROWTH AFTER RELEASE
INCREMENT CORE HT.
YEARS

FIG. 4. The effect of the removal of an aspen overstory on the annual growth of a balsam fir. A marked increase in 1931 indicates release occurred in 1930. The steady reduction in growth after 1940 results from increasing competition as the stand closes in the openings previously occupied by aspen.

During spring and summer transient beaver are responsible for cutting scattered trees but never more than a few individuals at any one spot. The only evidence of their brief presence is an occasional stump or possibly a cutting scar. Traces of these scattered cuttings occurring about abandoned flowages pose no serious problem when reconstructing the periods of use as the traces are unrelated to other evidence indicating actual occupancy. By fall these beaver restrict their activities to definite areas in preparation for the coming winter.

Evidence from Marginal Woody Vegetation of Abandoned Ponds: Evidence from marginal vegetation of abandoned ponds was used to indicate absence rather than presence of beaver. Usually a marked reduction in the water level immediately

follows the abandonment of the pond by beaver. However, there are exceptions, as water levels in some flowages show little change for several years after the beavers leave. When a drop in level does occur, even though the flowage is not entirely drained, a marginal strip of bare soil is uncovered. This strip makes an ideal seed bed for many species of woody vegetation. In the area where this study was conducted aspen, pin cherry, willow, alder, red maple, white birch, balsam fir, white pine and tamarack were the species most frequently encountered on the strip.

Beaver may abandon their ponds at any time from the spring break-up until late summer; however, most of the changes occur after midsummer. Thus the strip of bare soil is ready when the late summer and fall dispersal of seeds takes place. The seeds that are disseminated in the fall remain dormant for the winter and germinate the following spring. Aspen and willows are exceptions, producing their seeds in the spring. Germination occurs almost immediately after they fall on suitable locations. From the age of the woody vegetation that has become established on the strip, the year of abandonment of the flowage by beaver can usually be determined. However, repeated occupancy destroys most traces of former use; only evidence of the most recent abandonment remains. Also this evidence must be used with caution and checked against other evidence to avoid misinterpretation in those cases where the water level is not immediately lowered following abandonment. Care must be exercised in applying this technique in strips of water tolerant species such as alder and willow normally occurring along the margins of permanent wetlands and stream edges.

Evidence from Conifers Affected by Flooding: Evidence from conifers affected by flooding proved to be less useful than was first anticipated. Before attempting to use this evidence, it was necessary to make a preliminary study to determine what effect flooding had on the various tree species. Results of this study indicated that black spruce, tamarack, and white cedar could tolerate flooded conditions when growing on small hummocks not covered by water. However, these species were no more able to withstand complete flooding than were other conifers.

The effect of flooding on the annual radial growth of a tamarack growing on a hummock within the area of a former beaver flowage in shown by Fig. 5. Other tamaracks within the former pond area not situated on hummocks had been killed. The entire 10-year period during which growth was suppressed does not necessarily represent the period of occupancy of the flowage by beaver. Rather it indicates the period during which the dam held back the water. Beaver probably abandoned the flowage in 1932. This is indicated by the slight increase in growth after that season. A drop in water level and some improvement in growing conditions would normally follow abandonment. After 1938 the dam was no longer effective and the flowage was completely drained. When the dam went out, the impounded water enlarged and deepened the outlet partially draining the bog. Thus the growing conditions for the remaining black

spruce and tamarack were even better than the original conditions existing before beaver flooded the area. In order to avoid misinterpretation of evidence, cores should be collected from trees of the same species not affected by the flooding as well as from a number of the surviving trees.

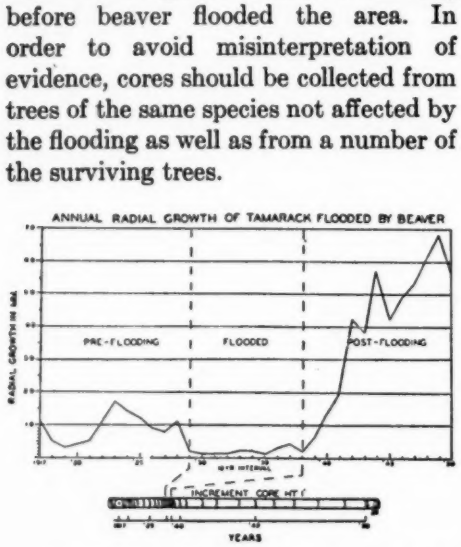

FIG. 5. The effect of flooding caused by a beaver dam on the annual growth of a tamarack. The sharp reduction in growth from 1929-38 indicates the period of flooding. After 1938 the pond was completely drained and growing conditions for the tamarack were greatly improved over original conditions existing prior to flooding.

Wilde et al (1950) in studying the effects of beaver ponds on soil fertility and forest growth, found stands (aspen?) on adjacent upland were slightly benefited by the raised water level. However, it is evident from the data presented that beaver flowages could not be aged by this method. The response is so slight that without prior knowledge of the pond's history, such a minor fluctuation in average annual growth would have little meaning.

EVIDENCE OBTAINABLE FROM SUPPLEMENTAL SOURCES

The evidence obtainable from supplemental sources are especially valuable as they provide a record of conditions existing in the field at a given time. When such records are available from different years for a given area, periods in which certain events took place, i.e., the appearance or disappearance of beaver ponds, can be established. Such information is invaluable to collecting and interpreting of field data.

General Land Office Survey Notes: General Land Office township plats and survey notes are among the oldest available historical materials describing specific localities. Even so, the information supplied by these notes and maps is rather limited, being based on observations and conditions encountered while establishing township and section lines. At each stream crossing the character of the stream, direction of flow, and width were recorded. As beaver ponds presented obstacles to the early surveyors, their presence was noted whenever they were encountered.

Land Office survey notes are available only for those lands once included within the public domain. Photostatic copies of these notes and plats may be purchased from the Bureau of Land Management, Department of the Interior. The same materials are usually on file and available for inspection at the Recorder of Deeds Office at most county seats.

Timber Cruise Reports: The reports of timber cruises provide another historical source of information concerning beaver activities during the early days before the forest was greatly altered by logging and the fires which followed. Accompanying these reports are sketch maps of the area surveyed. There is considerable variation in cruise maps from mere "written in" descriptions of the

land to very detailed type maps showing stream conditions. If beaver were responsible for flooding a considerable amount of timber, this was usually noted on the map. However, the usefulness of this source of evidence depends largely upon the care and detail with which the individual cruiser prepared his maps.

Cruise reports prepared for the early companies were especially valuable sources of evidence indicating the location of beaver flowages. The early logging companies needed accurate information about the lay of the land, the course and character of the streams, the location of hay meadows (beaver meadows) as well as the quantity of timber on an area. Thus these cruise maps were often drawn in great detail.

It is somewhat more difficult to locate these early reports as many of them were lost or destroyed when the old logging companies went out of business. However, if the companies are still in business either as logging or land office concerns, such records were kept and are usually available for inspection.

Stream Surveys: Various public agencies have at different times made stream surveys in connection with biological inventories. The survey maps, if prepared in detail, usually provide a wealth of information on the location and extent of beaver flowages.

The intensive stream surveys made by the CCC in the early 30's proved to be a very valuable source of data. All dams or flowages were indicated as active or abandoned. The mapping was done with sufficient accuracy to permit specific ponds to be readily located.

Copies of the CCC stream surveys conducted within national forests are on file at the local district ranger's office or at the national forest headquarters. State Conservation Departments will have copies of the stream surveys made on state lands.

Aerial Photographs: Of all the sources of supplemental data, aerial photographs give the most accurate and complete coverage. The use of stereo-pairs greatly facilitates the examination and interpretation of the photographs. In many instances stereo examination revealed the presence of abandoned flowages which were drained or partially drained. In regions where two sets of aerial photographs, taken a number of years apart, are available, it is possible to make comparison of the conditions existing in different years. Certain ponds will appear full on one set of pictures whereas on the other set the same ponds may be missing or drained. Vegetational changes can also be noted by comparing the two sets of pictures.

Enlarged portions of aerial photographs make excellent maps for field use. Exact locations of objects on the ground can be easily determined with the use of such a map.

Aerial photographs are available for purchase from such government agencies as the U. S. Forest Service, U. S. Geological Survey, Production and Marketing Administration (formerly AAA), Soil Conservation Service, and the Army. Sets of aerial photographs are on file at the district headquarters of the various government agencies concerned with land management. By contacting the local official, permission to study the pictures can usually be secured.

Evidence from Personal Interviews: The value of personal contacts with long term residents is obvious. These people can supply much information on the age and periods of occupancy of various beaver flowages. Information can usually be gathered more easily by making several short visits rather than from a single long interview. People's memories are not always accurate and therefore, whenever possible, information gathered in one interview should be cross-checked in later interviews so the inaccuracies can be detected.

CONCLUSIONS

Upon moving into a stream, beaver construct a series of dams in connection with their feeding activity. Each year more dams are built so that the longer beaver remain on a stream, the larger becomes the series. Concurrently the cutting areas become more and more extensive. If beaver have not previously been active in the area, the aging of ponds and determination of the history of beaver use is relatively simple. The record of use is then clearly written in the ring patterns of woody plants. However, in areas which have had a relatively large beaver population over the years, it is more difficult to trace the history of occupancy. Repeated use of pond-sites tends in time to obscure the traces of earlier use. Field sources of evidence, under favorable conditions, record the history of beaver activities over a period of 25 years. Earlier traces are often obscured by decadence, fire, logging and natural succession. Historical evidence from records and personal interviews, evidence from aerial photographs and stream surveys must be combined with the evidence collected in the field. When this is done a complete history of beaver occupancy can be reconstructed with confidence.

SUMMARY

1. In 1948 the writer undertook an ecological study of the relationship existing between beaver and forest vegetation in the Upper Peninsula of Michigan. In this project, it was necessary to determine the age of beaver ponds and the periods of their occupancy. Certain techniques were developed for this purpose and are presented in this paper.

2. Sources of evidence useful in aging beaver ponds are of two types: evidence obtainable from the analysis of annual growth rings of woody vegetation and supplemental evidence obtainable from historical records and interviews.

a. Vegetation within the beavers' zone of influence is subject to marked changes in growing conditions which favor some species and suppress or eliminate others. A study of the width, appearance and number of annual growth rings of samples collected from woody vegetation growing within this zone will reveal the sequence of these changes. These samples were collected from: callus growth covering beaver cutting scars, sprout growth developing in beaver logged areas, marginal vegetation of abandoned ponds, conifers released by beaver cutting activities, and trees affected by flooding.

b. General Land Office Survey Notes, timber cruise reports, stream surveys made in connection with biological inventories, aerial photo-

graphs and interviews with local residents, provided important supplemental data to the findings based on field observations.

3. In very few instances will all the above sources of evidence apply to any single pond. However, every piece of available evidence should be obtained and when this is done, a complete history of beaver occupancy of a pondsite can be reconstructed with confidence.

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FUR PRODUCTIVITY OF SUBMARGINAL FARMLAND[1]

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The problem of supplementing cash income on extensive areas of worn-out or impoverished farmland in some sections of eastern United States has grown to perplexing proportions. Many of these areas have been subjected to destructive soil erosion and over-cropping for generations, but are still farmed even though a high standard living is not produced. For the welfare of occupants of these lands it is desirable that methods of augmenting their cash income be investigated.

It seems probable that a sustained production of wild fur can be obtained from many of these areas, especially those with well-wooded tracts.

With this in view, a three-year (1943-46) study was conducted to determine fur productivity on a part of the Patuxent Research Refuge near Laurel, Maryland, an area consisting largely of submarginal lands.

THE AREA

The area selected for this study consists of a 1000-acre tract of gently rolling, partially wooded farmland adjoining

[1] The writers wish to express appreciation to Frank G. Ashbrook and Arnold L. Nelson for helpful supervision on this assignment. John Weigel, Hartman Rice, and Clyde Vance assisted in the trapping and preparation of skins. The late Harry Van Cleave, of the Animal Trap Company of America, offered many suggestions on trapping methods and helped to secure hard-to-get supplies. The New York Auction Company was responsible for special handling and grading of pelts.

a band of frequently inundated bottomland woods along the Patuxent River. This tract was farmed for 200 years or longer, with little or no regard to erosion control or overcropping, leaving the soil in an impoverished state. The area was hunted and trapped before its acquisition by the Fish and Wildlife Service in 1936 but the fur animal population had not been disturbed to any extent for five years previous to this study. Adjoining this study unit on its north and south sides are two extensive, largely wooded properties: Fort George G. Meade and the Experimental Forest of the Beltsville Agricultural Research Center. Additional to the continuous 1000-acre tract, the study area also included the margins of two lakes on the southern half of the refuge—one lake of 65 acres and the other 35.

MATERIALS AND METHODS

An attempt was made to harvest the fur crop much as the ordinary trapper would. However, detailed records were kept of every phase of the program.

Trapping

Kill-trapping was practiced throughout the study. Steel traps of suitable size were spot-set, usually along avenues of travel such as runways, holes under boundary fences, feeding and defecating posts and the like. Bait and scent sets were made using fish, fish oil, carcasses of trapped animals, and urine and scent glands of trapped animals. Maps were made showing location and type of set. Notes were made of time set was made or altered and of all catches or disturbance of set. Traps were run once a day, usually early in the morning.

Trapping was carried on for three seasons as follows: November 1, 1943 - April 6, 1944; October 23, 1944 - March 15, 1945; and November 15, 1945 - March 8, 1946.

Preparation and Disposition of Pelts

As soon as practical after killing, the animals were skinned, and pelts were fleshed, stretched and allowed to dry. The killing process varied somewhat with different species. Foxes were usually killed by heart pressure—sometimes they were stunned first with a club. Skunks were usually shot with a .22 rifle. Raccoons and opossums were shot or killed by heart pressure. Muskrats were usually drowned automatically by the type of set used or, if found alive, they were killed by clubbing.

Practically all skins were case-handled. After skinning, they were fleshed and surplus fat was removed. Care was taken not to over-scrape the pelts. Skins were stretched on boards of suitable shapes and sizes made from quarter to half-inch stock. Furs were allowed to air dry at cool-room or out-of-door temperatures. When a sufficient quantity had accumulated, and at the close of the season, pelts were shipped to the New York Auction Company. They were then sold at regular auctions. Some skins withheld from sale were dressed by commercial firms and used in fur-fiber research by the Fish and Wildlife Service and, at present, form a part of the reference collections of the Patuxent Research Refuge.

Supplemental Data

All animals handled were weighed, sexed, and, if possible, aged. Ecto-parasites were removed before the animal cooled. The carcass was necropsied

after being pelted. Endoparasites were removed and preserved and pathological conditions, if any, were noted. Bacteriological cultures were made from the vital organs of a few of the animals. Stomach contents and intestinal tracts suitable for food habits analyses were preserved for future study. Carcasses deemed palatable for human consumption were sent to the Fisheries Technological Laboratory at College Park, Maryland, where they were prepared in various ways and their suitability for the table tested. Data on food habits and parasites are not included in this paper.

ECOLOGICAL DISTRIBUTION OF CATCH

The catch of fur animals was plotted on vegetational maps of the study area according to year and species. The location and take of each trap set was also tabulated for each year so that a comparison of trap effectiveness could be made. The vegetational types described by Hotchkiss and Stewart (Vegetation of the Patuxent Research Refuge, The American Midland Naturalist, Vol. 38, No. 1, July 1947) were followed with two exceptions: A lake border type was added and road and trail margins were considered a part of "Hedgerows and Wood Margins." In tabulating the catch by vegetation types, actual trap location and also the surrounding areas in which the animal lived were taken into account. Attractions such as cornfields or other food supply were also considered. A summary of this information is given in Table 1.

Productivity of Habitat Types

Hedgerows and wood and road margins proved to be the most productive habitats. This confirms the belief that a majority of animals follow or use wood margins, hedgerows, roads, and trails as travel lanes to and from home dens and food supplies. This habitat also provides a food supply for a variety of species. Of the eight species of fur animals under discussion, only the muskrat and mink were not taken in the hedgerow-wood margin type. Bottomland forests were also quite productive with all species represented but, considering the number of sets, the catch was less than in the above type. Marshy lake-borders were productive, in proportion to the number of sets, but the catch was limited mainly to muskrat and raccoon. This was to be expected, for these sets were made especially for muskrats. The raccoon take indicates that such a habitat is good feeding ground for them.

The catch in cultivated fields was mainly raccoons—evidently attracted by the corn. It is easy to pick out the cornfields on a map of the study area when the raccoon catch is plotted. Opossum and skunk were the other species caught most often in this habitat type. Approximately 85 percent of the catch of all species was made in the four habitats discussed. The remaining 15 percent was scattered through eleven other habitat types.

Opossum:—About three-fourths of the 41 opossums were taken in three vegetational types: hedgerows and margins (14), well-drained bottomland forest (10), and cultivated fields (8). Five were scattered among other forest types, three were taken in swamps, and one in an old fallow field.

Muskrat:—Of the 79 muskrats caught, 65 were taken in special sets along the

TABLE 1.—ECOLOGICAL DISTRIBUTION OF CATCH

Habitat	Trapping Season	No. Traps	Catch							
			Opossum	Muskrat	Skunk	Raccoon	Gray Fox	Red Fox	Total	Percent of total
Marsh Meadows	1943–44	2							0	
	1944–45	3							0	
	1945–46	2				1			1	
	Total	7				1			1	0.3
Marshy Lake-Border	1943–44	6		10		6			16	
	1944–45	8		38		3			41	
	1945–46	12		17		2			19	
	Total	26		65		11			76	19.4
Transition Swamps	1943–44	1				1			1	
	1944–45	3				1			1	
	1945–46	9				2	1		3	
	Total	13				4	1		5	1.3
River Swamps	1943–44	2				2			2	
	1944–45	7							0	
	1945–46	10				2			2	
	Total	19				4			4	1.0
Bottomland Forest	1943–44	23	2	2	1	14	1	3	23	
	1944–45	28	5	2	1	4	3	2	17	
	1945–46	39	3	10	2	16	3	3	37	
	Total	90	10	14	4	34	7	8	77	19.6
Seepage Swamps	1943–44	6	2		1	1			4	
	1944–45	10	1			1			2	
	1945–46	2			1	5			6	
	Total	18	3		2	7			12	3.1
Terrace and Bluff Forest	1943–44	7				2			2	
	1944–45	12	1						1	
	1945–46	3					1		1	
	Total	22	1			2	1		4	1.0
Upland Oak Forest	1943–44	9				2			2	
	1944–45	8	2						2	
	1945–46	6				3			3	
	Total	23	2			5			7	1.8

marshy borders of the lakes. Only 26 traps were used but these were moved about to take advantage of runways, feeding posts and other signs. The remaining muskrats were taken along the forest-bordered Patuxent River.

Skunk:—The most effective habitat by far for skunks was the hedgerow-margin type bordering open fields or grasslands. Of 76 skunks taken, 48 were caught in this type of habitat. Eleven were taken in cultivated fields and seven were caught in pine-oak forest. Bottomland forests and aban-

TABLE 1.—ECOLOGICAL DISTRIBUTION OF CATCH—Continued

Habitat	Trapping Season	No. Traps	Catch							
			Opossum	Muskrat	Skunk	Raccoon	Gray Fox	Red Fox	Total	Percent of total
Sweet Gum Fields	1943–44	2							0	
	1944–45	5				1			1	
	1945–46	4				2			2	
	Total	11				3			3	0.8
Abandoned Fields	1943–44	3			1	1			2	
	1944–45	7	1						1	
	1945–46	5			3				3	
	Total	15	1		4	1			6	1.5
Pine Fields and Pine Stands	1943–44	6				2			2	
	1944–45	6	1						1	
	1945–46	6							0	
	Total	18	1			2			3	0.8
Pine Oak Forest	1943–44	5			3				3	
	1944–45	6			3		2		5	
	1945–46	5	1		1				2	
	Total	16	1		7		2		10	2.6
Cultivated Fields	1943–44	13	3		3	7	1		14	
	1944–45	12	3		2	3	1		9	
	1945–46	18	2		6	8			16	
	Total	43	8		11	18	2		39	9.9
Pastures	1943–44	4				2			2	
	1944–45	3							0	
	1945–46	3							0	
	Total	10				2			2	0.5
Hedgerows and Wood and Road Margins	1943–44	42	5		20	7	13	11	56	
	1944–45	22	6		10	3	17	6	42	
	1945–46	23	3		18	5	17	2	45	
	Total	87	14		48	15	47	19	143	36.5
Total	1943–44	131	12	12	29	47	15	14	129	
Total	1944–45	140	20	40	16	16	23	8	123	
Total	1945–46	147	9	27	31	46	22	5	140	
Grand Total		418	41	79	76	109	60	27	392	100.0

doned fields each supplied four and the remaining two were taken in swamps.

Raccoon:—Raccoons led the catch with a total of 109. The outstanding habitat type for this species was bottomland forest, where 34 were taken. Cultivated fields (18), mainly those with corn, and hedgerows and wood margins (15) were also good habitats, particularly if leading to cornfields. Eleven raccoons were caught in muskrat sets along lake borders and 15 were taken in three swamp habitats. The remaining

16 were caught in seven other types of vegetation.

Gray Fox:—Most of the fox catch was made from sets placed along roads, trails, and paths. Of 60 gray foxes, 47 were credited to the hedgerows and margins habitat. Seven were taken in bottomland forests, mainly along trails or roads, and the remaining six were scattered among several other habitats.

Red Fox:—Sets for red foxes were the same as for grays, and the distribution of catch is similar. Over two-thirds of the take (19 out of 27) came from hedgerows and the remaining eight were caught in bottomland forests.

Mink and Weasel:—Eight minks and four weasels were caught during the three trapping seasons. All of the minks were captured near water—two along lake margins, one by a small stream, and the remainder along the Patuxent River. After the close of this project, five additional minks were trapped while preying upon caged experimental birds in the refuge headquarters area. The four weasels were scattered, with two being taken along hedgerows, one in upland forest and one along the Patuxent River.

ECONOMIC VALUE OF FURS TAKEN

All furs were carefully graded by the New York Auction Company and those not needed for other purposes were sold at public auction. Prices of muskrat and opossum pelts would have been higher except for war-time restrictions. On the other hand, prices received for some of the long-haired furs were high as compared to present offerings. In estimating the total value of the furs, an average was found for those pelts that were sold and this was applied to the skins that were retained as specimens. This method probably resulted in a slight under-estimate of value since most of the skins not sold were of the better grades.

In this study no attempt was made to account for the hours of labor involved, since trapping of this nature is usually considered to be a spare-time or off-season activity. The only items usually thought of as chargeable to the gross income are equipment, transportation, postage, and other incidentals.

For the three-year period the gross revenue from the 392 animals pelted was $1119.00. The income for the seasons separately was $389.05 for the first, $334.55 for the second, and $395.40 for the third. The slump for the second year is attributed to freezing cold that prevailed for a considerable period, making traps inoperative and decreasing the movement of certain mammals as well as to lower pelt prices on some species. There would have been a slight addition to the gross amount if the carcasses of those animals commonly used for food had been sold. During this period the value of muskrat meat ranged from 25 to 35 cents per animal. The raccoon carcass, although much heavier and, if properly prepared, usually just as palatable as the muskrat, does not have market value.

The raccoon was the top species both in numbers and in gross value. A total of 109 raccoons were trapped and the skins of these brought $278.80, an average of $2.55 per skin. During the second trapping season, the raccoon catch was only about one-third as great as in either of the other years. As mentioned before, this is thought to have been due mainly to the severe cold

period rather than to a reduction of the population. The muskrat ranked next, with 79 skins averaging $2.90 for a total of $229.10. The return on its pelts was greatly reduced because of government war-time restrictions on prices. For example, the average price received during the first two seasons was about $2.30 per skin but after removal of restrictions those taken during the last season averaged $4.10. The muskrat probably returned the greatest profit on time and labor of any of the more plentiful species.

Only a few minks (8) were taken but the high average price of almost $21.00 put them in third place. At this time the trend had started toward a style demand for short-haired furs. Thus the price of minks advanced, while a decline was occurring in the price of fox and some other long-haired furs. Red foxes taken the first season averaged $6.30 per pelt while those sold two years later brought only $3.00. However, since 22 of the 27 red foxes caught were taken the first two years of trapping, they averaged about $5.75 for a total of $155.20. Grays were much lower in average value ($2.20) but the number caught (60) was more than twice the number of reds, so the total value of $132.25 approximates that received for the red foxes.

Opossums were really the "drug on the market" during this study. Skins averaged only about thirty-five cents each, hardly paying for equipment and leaving nothing for labor. The 41 opossum pelts brought $14.95. Only four weasels were caught and these averaged about a dollar per pelt. This is a figure considerably higher than previous market prices.

The fur trapping project represented a gross income of approximately forty cents per acre per year. This is based upon the 1000-acre study area and no attempt is made to pro-rate the effect of adjoining areas which might have served as a reservoir. No doubt this return could be duplicated on many areas of both good and sub-marginal land in the East. It would represent a sizeable sum for many school boys and an appreciable supplementary income for farmers or their tenants during off-seasons.

RECOMMENDATIONS FOR MANAGEMENT PRACTICES

Because of the comparatively small returns realized from trapping fur animals the average farmer or tenant can ill afford to spend much time or money in activities intended to promote fur production. Management recommendations to be acceptable must tie in with approved agricultural or forestry practices and at the same time must be of such scope as to be economically practical for the farmer, forester or other landowner. Where a harvestable crop of fur is sought, important food plants should be encouraged in hedgerows, fencerows, woods borders, or elsewhere. A considerable portion of the food of many game and fur animals consists of pulpy fruits and berries such as persimmon, wild grape, pokeberry, and blackberries. The mast crops, particularly from oaks and nut trees, are also important. Introduction of food plants can often be accomplished at low cost in the planting of hedgerows and borders. It should be borne in mind that mast-bearing trees and shrubs found in open

or uncrowded places are often the best producers of food.

In lumbering operations, thought should be given to saving a scattering of mast and den trees—several to the acre. Maintenance of fire trails, as well as logging and service roads, is good forestry practice. The latter improvements also facilitate movement of fur bearers and create the edge effect so desirable in wildlife management. Where den trees are insufficient, low-cost nest boxes made of cull material may serve as dens and help to produce a greater population of fur animals.

Marsh management has economic potentialities that are just beginning to be realized. Creating shallow-water ponds and marshes in basins of low agricultural value and where the watershed or water supply is sufficient may result in significant populations of fur and game species. In some areas, soil conservation districts or state game agencies are willing to cooperate with the farmer in constructing impoundments for such purposes. In new ponds or marshes the establishment of suitable food and cover vegetation can be hastened by plantings. For muskrats, cattails, bulrushes, burreeds, and arrowheads are recognized as particularly valuable.

SUMMARY

A submarginal tract of a thousand acres on the Patuxent Research Refuge, Laurel, Maryland, was trapped for three seasons (1943-46) to determine the fur-productivity of the area.

The tract yielded 392 fur animals, the pelts of which were sold at public auction for $1119.00. This resulted in an average income from trapping of approximately forty cents per acre per year.

The habitats most productive of catches of fur animals were hedgerows and wood and road margins, followed by bottomland forests and lake margins.

Some suggestions for improving habitat for fur animals are given.

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TRAPPING AND MARKING OF ADULT NESTING DOVES*

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The number of birds fledged per female, movements of pairs during the nesting season, and permanency of mating were some of the unknowns in the life history of the mourning dove (*Zenaidura macroura*) in Texas. To get data on these important subjects, one must be able to identify positively a number of pairs of nesting birds. This means trapping adult birds on the nest; marking them, and following them throughout the nesting season. A review of the literature failed to reveal a trap suitable for this purpose, so one was designed, built, and tested. Because the designed trap is inexpensive, easy to build, and has proven efficient, the design and our experience in operation are here presented for use by other wildlife biologists.

Construction

The body of the trap is of 1 x 2 inch mesh galvanized welded wire (Fig. 1). A piece of this wire, 12 x 21 inches, is bent into a flat-topped inverted U-shape to produce a three sided form 12 inches long, 7 inches high and 7 inches wide. Doors at each end are made of the same material, and slide freely in U-shaped galvanized sheet iron channels soldered to the body of the trap. The release mechanism consists of five wire loops soldered to the top of the trap, with wire pins running through the two at each end. Fine flexible wire cable (fishing leaders) run from these pins through the center loop. The length of these cables is adjusted to release both doors simultaneously, then soldered together near the loose ends. A release cord (an inexpensive, preferably black, fishing line) is attached to the release cables when the trap is in operation. This extends to the ground or for some distance away from the nest, enabling the investigator to release the trap without flushing the intended victim.

The versatility of the trap is due to a 24 x 36 inch piece of cord netting that forms the floor. A badminton net will make five such pieces. The mesh is small enough to prohibit doves from going through, yet large enough to blend in with the surrounding vegetation. The net is larger than the bottom of the trap to allow for closing in around limbs radiating from the nest, or other such obstructions. Safety pins are used to secure the net to the trap and to close it in around branches.

Traps and safety pins that we used were painted black; however, I do not know that this is necessary for tests were not made to determine if birds shy away from unpainted metal parts.

Operation of the Trap

Best results were obtained by trapping adult birds from nests containing young that were four to eight days old. Younger

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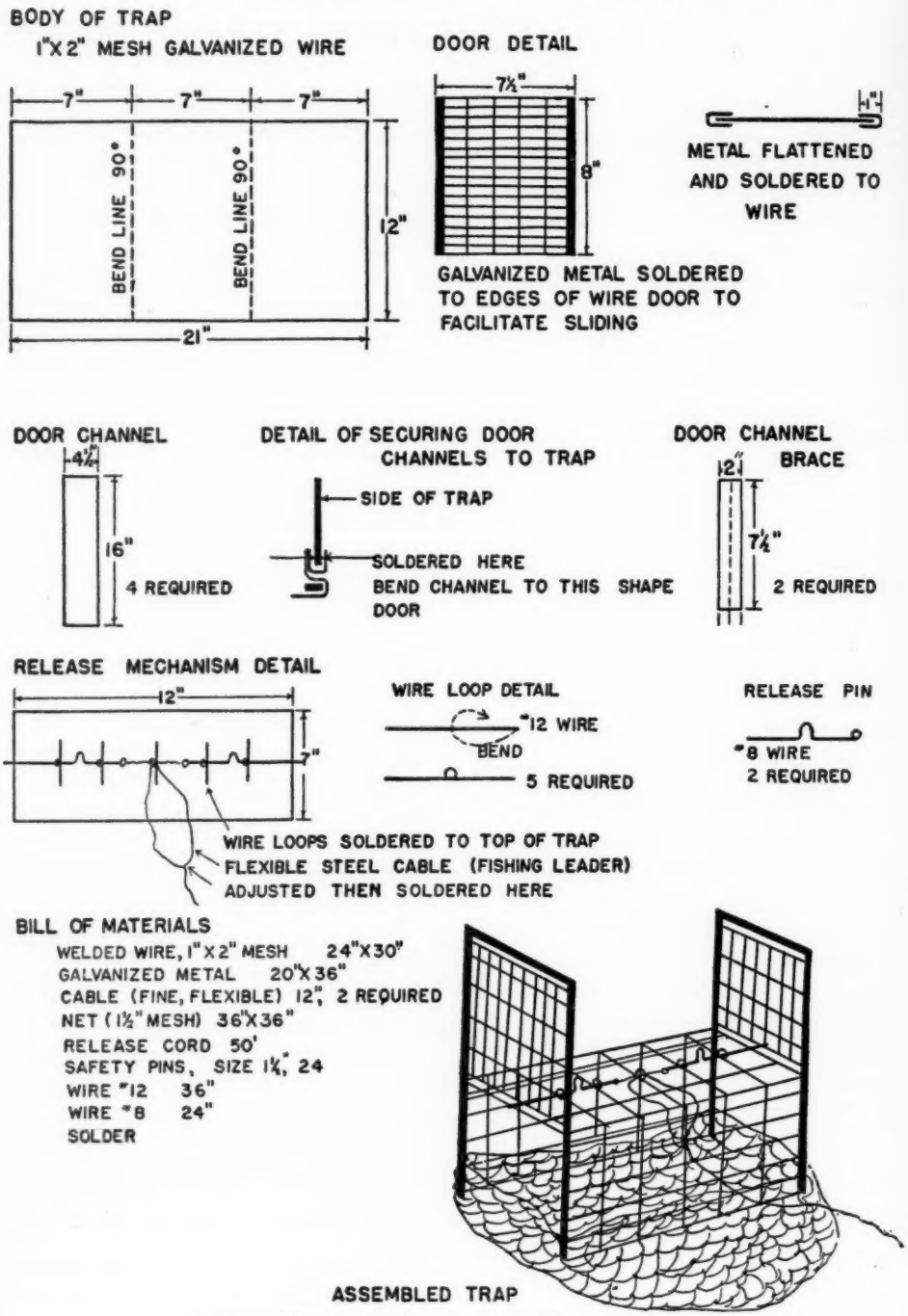

FIG. 1. Plans for the construction of dove nest trap.

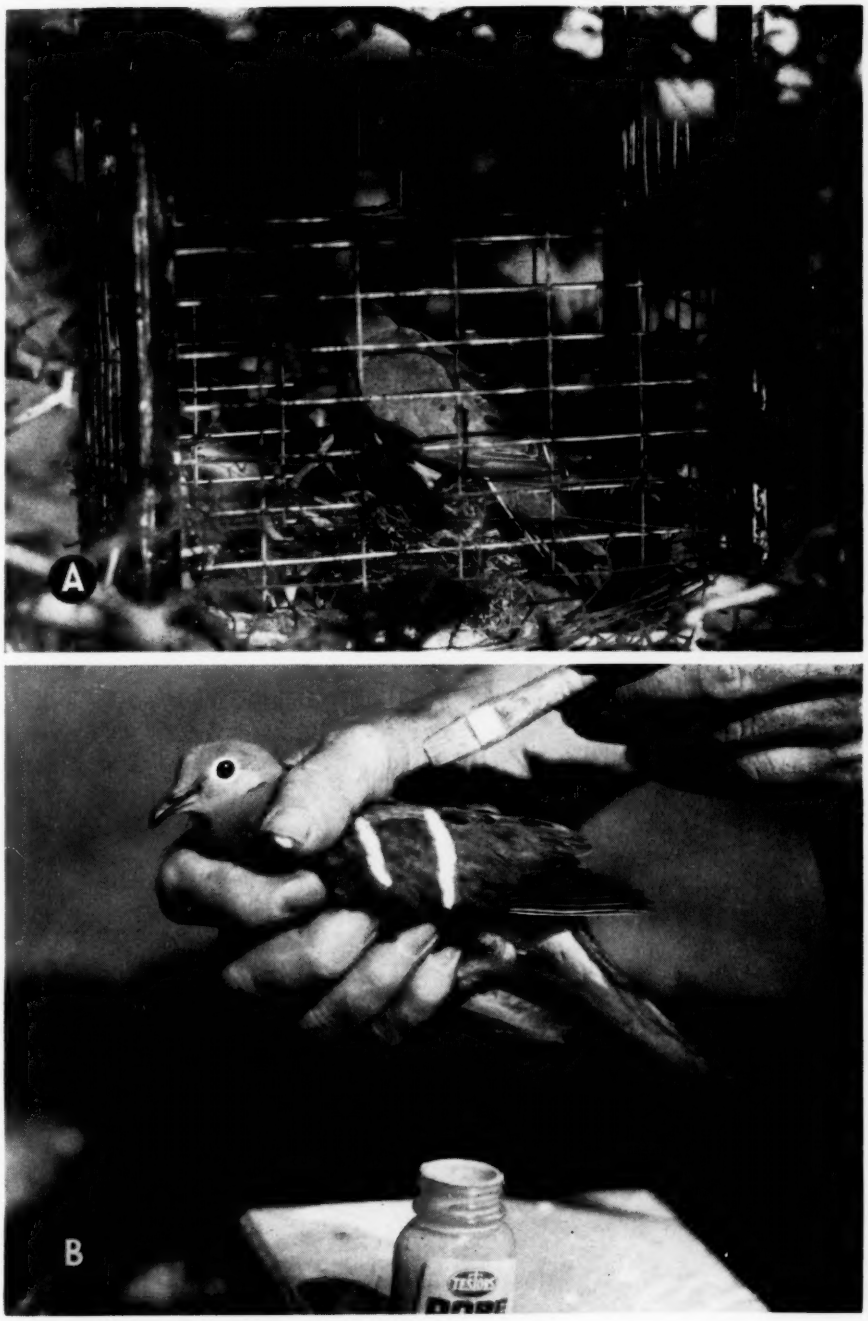

PLATE 2A. Nesting dove captured with nest trap.
2B. Marked wing coverts were easily observed, but were usually molted before the end of the nesting season.

birds may be injured by the adult through its frantic efforts to escape, while birds older than eight days are approaching the stage where they are no longer good "bait." They fly readily and are agile enough, when coaxed by the parents, to move out of the nest and the trap to an adjacent limb, thereby thwarting efforts to trap the adults. Attempts should not be made to trap incubating birds, because nests containing eggs are abandoned more readily than those containing young. Trapping operations should be discontinued during periods of inclement weather because the young doves may become chilled or damp during the period required for the adult to get up enough courage to enter the trap.

The body of the trap is placed over the nest and oriented so the bird can enter by its usual route. The net floor is then brought under the limb supporting the nest and pinned to the trap. Fastening the net floor will usually stabilize and secure the trap, but occasionally it may be necessary also to tie it to a nearby limb. It is advisable to bring the net up on each end so there will be an overlap of net and door when the trap is sprung. If the nest location necessitates tilting the trap at an angle it has been found advisable to loop one end of a rubber band around a horizontal wire on the door and hook the other end over a wire on the trap body. This takes but a few seconds, and greatly increases the rapidity with which the doors close, thereby reducing the number of birds that escape.

Before leaving the set trap a last minute check should be made on the release mechanism to see that it is operating efficiently. An examination should also be made of the netting, to disclose any spaces through which the bird might escape. That end of the release cord near the ground should be placed against the trunk of the nest tree or concealed in some manner from passers-by.

The trap could be made automatic by modifying the release mechanism, but since doves brood continuously no advantages would be offered. Furthermore, through their efforts to escape, the possibility would be increased of adult birds injuring themselves as well as their young when trapped in the absence of the operator.

Best results were obtained by setting traps from 8:30 a.m. to noon. From 3:00 p.m. until 5:30 p.m. trap sets were examined and traps were sprung where an adult was on the nest. In practically all cases it was the males that were taken at this time of the day. If the adult was captured, or if it was on the nest when the operator approached, but escaped, the trap was reset. If the adult bird was not on the nest the crops of the young were examined to determine if they were being fed. If their crops were empty, the trap was removed; however, if they were full, the trap was left intact. Females were best trapped from about one half hour after dawn until 8:00 a.m. They entered the traps more readily than males, and in one instance a female re-entered a trap within an hour after she had been trapped and released. Several times birds that had been previously captured entered the trap when I was trying to catch their mates. In one instance I retrapped a pair of birds 58 days after they were first captured and released. Of attempts made to trap 106 birds, only twelve (11.4%) were unsuccessful. One pair coaxed the nine day

young out of the nest onto an adjacent limb; four (two males and two females) would not go into the trap; four escaped under the doors of the trap before they closed completely or went through an unobserved hole in the net floor; one male entered the trap several times but flew before I could get close enough to pull the release cord, and one female fed her offspring but did not stay on the nest long enough to present an opportunity to catch her.

Various birds reacted differently when the trap was sprung. Some seemed not to notice that they are trapped and continued to sit quietly on the nest until the operator began to climb the tree. The majority, however, tried frantically to escape as soon as the release cord was pulled. Every effort should be made to get to the trap as quickly as possible when birds react in this manner in order to reduce injury to both adults and young.

Birds captured in trees were brought to the ground by placing them either in my shirt pockets, which had button-down flaps, or in a small cloth sack with a drawstring.

MARKING

Trapped doves were marked with Testors Model Airplane Dope. White and yellow were found to be the only satisfactory colors. Orange was undesirable because it looked too much like yellow when visibility was poor. Other colors were too dark to stand out on the dull background of the dove's feathers. Only large feathers of the wings and tail were found to be satisfactory surfaces for marking. Painted body feathers were soon pulled out by the constant preening, or the marking material was broken up so finely that its adhering qualities were soon lost.

Feathers of the wings and tail should be spread when the marking material is applied, and held in this position for a couple of minutes to permit the dope to dry before the bird is released. Adult doves begin molting in mid-summer, so if it is desirable for the bird to carry a distinguishing mark until the end of the nesting season, the outer primaries should be marked. These are the last feathers to molt, and in Texas they are usually not lost before October. The greater primary wing coverts are molted about the same time as the primaries, so these can also be used; however, they do not show up as readily as the primaries.

Distinct solid lines were found to be the most satisfactory designs. Intricate patterns quickly lost their value, because portions of them disappeared and it was impossible to identify the bird. Birds marked with solid lines were in several cases identifiable from May until September; while those marked with numbers, letters, and other such patterns, were not distinguishable for more than a few weeks. It was found advisable to paint the tip of the underside of the tail of all marked birds with yellow dope. The long tail of the mourning dove projects far enough beyond the border of the nest, that the yellow on the underside of the tail can be readily seen on nesting birds.

The airplane dope was applied with a small brush. Thinner should be used to clean the brush and to keep the dope at the desired consistency.

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STUDIES OF THE REPRODUCTIVE CYCLE OF THE BOBWHITE QUAIL

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Introduction

It is generally agreed among wildlife management authorities that the propagation and release of the bobwhite quail (*Colinus v. virginianus*) is not an important or desirable aspect of bobwhite management. The authors take no issue with this well established fact. This work was initiated to study the physiology of reproduction of the bobwhite as regards stimulation of the gonads by light, age at sexual maturity, and the possibility of polygamy. The authors believe that in a study of this nature, captivity has little if any influence on the validity of the data which should prove useful to the wildlife manager as well as the bobwhite propagator.

Age at sexual maturity has not been reported in the literature. Polygamy was reported by Brill (1934) using ratios of from one male to two females, to two males to seven females. In the same paper he reported stimulation of the bobwhite by light in midwinter. In this experiment, however, he used pens 6 x 12 feet in dimension. The production of fertile eggs in response to light has been reported for the bobwhite by Bisonnette and Csech (1936a and 1936b), and Clark, *et al.* (1936 and 1937). All of these reports deal with increasing light and indicate that the light increment is an important factor.

Methods and Results

As a preliminary trial, three pairs of bobwhite quail were put under the continuous light of an incandescent bulb on November 16, 1949. They were placed in a cage measuring three feet long and two feet wide, and one and one-half feet high. The birds were hatched on August 11, 1949, and were 98 days old at the start of the light stimulation. The first egg was laid on December 27, 1949, 41 days after the start of the light stimulation. Soon after that all three birds were in production and laid 153 eggs up until May 1, 1950, when the birds were transferred to outdoor cages, where they continued in production through June. The time to sexual maturity as determined by the age at first egg was established at 139 days.

This test was repeated in the fall and winter of 1950 on a larger scale with some modifications. The birds were kept in a starting battery such as is used to brood chickens, without supplementary heat. Twelve pairs of quail, one pair to each compartment measuring 36 inches long, 30 inches wide, and 9½ inches high, were put into the battery. Each compartment was equipped with a small 10-watt bulb which was kept on continuously starting October 7, 1950. The entire room was kept bright by the use of two 200-watt bulbs. Three females and

[1] Journal Paper No. 534. The authors are indebted to the Indiana Department of Conservation for eggs, quail chicks, and outdoor holding facilities for this experiment.

one male were also put in the 2′ x 3′ cage to test multiple matings. All these were kept in a basement room at a temperature of 40° to 50° F. and fed a 23% protein mash, oyster shell, and water *ad libitum*.

The eggs were collected and marked with pair number and date of lay. The eggs were then set in incubators at two-week intervals to determine fertility. The first egg was obtained on November 14, 1950, from a bird that was hatched on June 5, 1950. In all, 9 pairs of birds were induced to lay and all three birds in the multiple mating group were stimulated into egg production. Results obtained from the various matings are given in Table 1.

TABLE 1.—AGE AT SEXUAL MATURITY, EGG PRODUCTION IN 79-DAY WINTER PERIOD, AND FERTILITY. (ALL QUAIL HATCHED JUNE 5, 1950 EXCEPT PAIR NO. 9 HATCHED AUGUST 14)

Pair No.	Date of First Egg	Days to Sexual Maturity	Total No. of Eggs Per Bird	Fertility
1	11/23/50	171	13	80%
2	11/28/50	176	40	92
3	12/1/50	180	18	89
4	12/5/50	184	33	62
5	11/21/50	169	36	97
6	12/1/50	180	37	95
7	12/2/50	181	7	57
8	11/14/50	162	30	90
9	1/21/51	160	3	0*
M.M.	11/24/50	172	42**	73

* This pair continued in production and produced fertile eggs after January 31, closing date of above test.

** Multiple mating of 1 male and 3 females; total production of 3 females was 127 eggs, average 42 eggs.

A total of 344 eggs were obtained over a period of 79 days from November 14, 1950 to January 31, 1951 from a total of 12 birds. The production was from 3 to 40 eggs per bird over this period, for those birds mated in pairs. In the multiple mating pen, the average production was 42 eggs per bird.

DISCUSSION

This work demonstrates that the bobwhite quail can be induced to reproduce at a time other than the normal breeding season while confined in a very limited space. Although no attempt was made to determine the minimum amount of floor space required, 1080 square inches were allowed for each single pair and only 864 square inches were given to the 4 birds (216 sq. inches per bird) in the multiple mating, all with favorable results. These facts may be used to advantage by the propagator. Although, as generally practiced, propagation and release of the bobwhite is unfavorably regarded by game management technicians, many thousands of quail are reared in captivity each year by state game commissions and private individuals. According to Buechner (1950) cost of hatchery production varies from 68¢ to $3.00 per bird, and low survival on release results in a cost per bird killed by the hunter of $2.80 to $55.56.

Recognizing that the popularity of this widespread, costly activity will slow up sudden revolutionary changes, the results of this experiment, nevertheless, offer the opportunity for more efficient production. Savings in time, space, equipment, labor, winter holding costs, and disease loss due to improper sanitation, are possible with the set-up described here. These savings could very well be applied to more desirable game management practices.

The bobwhite quail is subject to light stimulation apparently through the pituitary-gonad axis, and it is therefore possible to have available young bobwhite quail for research purposes the year around. It is not necessary to limit

research concerning the juvenile bobwhite to the normal breeding season if use is made of the methods described in this paper. Work in progress at this laboratory indicates that the bobwhite quail is a very desirable animal for the study of nutritional and physiological problems.

In the wild, the bobwhite quail normally does not come into egg production until the latter part of April. First game farm birds to come into production on a game farm in this latitude did so on May 4 in 1950 (Kirkpatrick, *et al.*, 1951). This does not mean that the quail are not sexually mature until then. This work shows that the bobwhite is sexually mature and can be induced into full productive capacity long before this time. Sexual maturity in the bobwhite is established as ranging between 139 and 185 days of age. It is apparent that it is physiologically possible for an early hatched bird, the so-called juvenile, to lay a clutch of eggs during the same year it was hatched. The probability of this occurring in the wild does not seem great but the possibility exists.

In the wild, the bobwhite is monogamous. Polygamous mating, however, has been demonstrated in this experiment as indicated by a 73% fertility of 127 eggs produced by three females mated with only one male. This probably does not happen in the wild but the indications here are that it is a matter of choice with the bobwhite and not a physiological impossibility.

This work demonstrates also that continuous light is effective and that daily increments of light are not necessary as has been previously reported.

CONCLUSIONS

1. The bobwhite quail can be stimulated (by continuous light) probably through the pituitary-gonad axis to reproduce during other than the normal season.

2. Under these conditions the bobwhite quail:

   a. may attain sexual maturity as early as 139 days of age.
   b. may be polygamous.
   c. may be made available at any age for research purposes at all times of the year.

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OBITUARY

LOUIS BENNETT BISHOP

Dr. Louis B. Bishop, a charter member of the Wildlife Society, was born on June 5, 1865 at Guilford, Connecticut. He died April 3, 1950 after a full and productive life as a physician and an ornithologist of note.

His interest in wildlife dated from his early childhood when, at the age of six, he collected his first bird with a slingshot. This bird became a part of the Bishop collection, which at the time it was transferred to the Chicago Natural History Museum, numbered 53,000 specimens.

The elder Bishops occupied a prominent place in Connecticut society and after attending private and grammar schools in New Haven it was expected that Louis should be educated in one of the professions. He chose medicine as did his father and grandfather before him. He received his MD from Yale in 1888, carried on additional studies at the New York Polyclinic Medical School and served his interneship at the New Haven Hospital in 1889–90. After two years of travel and study in Europe he returned to New Haven and opened a private medical practice.

Although he was successful in the medical profession his real interest was ornithology. He spent many vacations collecting and studying birds and their eggs, and his ornithological trips between 1895–1916 took him to North Dakota, Florida, British Columbia, Alberta, Saskatchewan, Nova Scotia, Magdalen Islands, California, Massachusetts, New Hampshire, Virginia and South Carolina.

His first published ornithological note was in 1885 in which year he also joined the American Ornithologists' Union. He was elected as a Fellow of the A. O. U. in 1901.

In 1908, after 15 years of medical practice, he retired in order to devote full time to birds. In 1910 he married Leona Anna (Bayles) Sturtevant. After a year's trip to Europe and Africa the Bishops' one child, Herbert Bennett, was born in New Haven, in 1912. In 1917 they moved to California spending the winters at Hollywood and the summers at Carmel until a permanent residence was established in Pasadena.

A member of more than 30 professional societies and clubs and author or co-author of at least 67 ornithological publications, his death was a distinct loss to the wildlife profession.

Dr. Hildegarde Howard, Chief Curator, Division of Science, Los Angeles County Museum, kindly provided the material upon which this account is based. For a more detailed biography readers are referred to Dr. Howard's article which appeared in the AUK, **68**(4): 440-446.—D. L. LEEDY, *U. S. Fish and Wildlife Service, Washington 25, D. C.*

CORRECTIONS

CENSUSING ELK BY AIRPLANE IN THE BLUE MOUNTAINS OF WASHINGTON

In an article published under the above title in the Journal of Wildlife Management, Vol. 15, No. 1, pp. 81-87, the statement was made on page 86 that the theoretical rate of increase for an established herd of elk was 26 percent. Dr. George H. Kelker pointed out to me that this is an error resulting from Leopold's system of numbering in which year one is the nonbreeding year (see table on p. 456 in Game Management by Aldo Leopold). Actually the average yearly increase for the last ten years of Leopold's table is 30 percent, starting with 288 animals and ending with 3,878. This error in no way invalidates the conclusions reached in the published article.—HELMUT K. BUECHNER, *Wildlife Management, State College of Washington, Pullman, Washington.*

WISCONSIN PHEASANT REPRODUCTION STUDIES

Errata — Wisconsin pheasant reproduction studies based on ovulated follicle technique by Irven O. Buss, Roland K. Meyer and Cyril Kabat, Jour. Wildlife Mgt. **15**(1): 32-46:

Page 36, beginning with line eight the text should read—These pheasants laid from one to four clutches, and 10 of the 11 hens laid clutches in nests that were abandoned for reasons that appeared to be completely unrelated to environment. A total of 32 clutches was laid by the game-farm hens, but only 11, or 34 per cent, were incubated.

Page 37, Table 2, the average 5.8 should read 11.5.—IRVEN O. BUSS.

REVIEWS

The Elk of North America. Olaus J. Murie. The Stackpole Company, Harrisburg, Pennsylvania and The Wildlife Management Institute, Washington, D. C., 376 pp. illus. 1951. $6.50.

Murie has succeeded in his intention to assemble the principal facts in the distribution and life of the elk of North America, and to offer suggestions, based on the studies made, for future elk management. Five sub-species of *Cervus canadensis* are recognized in America, the eastern form being extinct; *C. nannodes*, the tule elk, and four fossil forms are described. Early records of elk distribution are given and one is impressed by the great variety of range that was occupied across the North American continent, ocean to ocean, and from Texas to northern Canada.

In his chapter on elk habitat, Murie resolves the controversy concerning whether the elk is primarily a plains or mountain species by concluding that "the elk have always been at home in the mountains as well as on the plains," and that the genus as a whole is highly versatile and adaptable.

Approximately 50 pages are devoted to careful descriptions of physical characters as size, pelage, antlers and their development, the teeth and their development and wear, tracks and gait and their vocal habits. This chapter permits the author to exploit his fine talent as an artist and it is copiously illustrated by many excellent line drawings and photographs. Game technicians and sportsmen alike should profit greatly from the descriptions and illustrations of age classes from known-age specimens. He relies principally upon analysis of the stages of tooth replacement and patterns of tooth wear for diagnosis of age-classes from the calf of a few months to the adult 4-1/2 years old.

Murie's treatment of the chapters on reproduction and natural mortality factors including predation, accidental deaths, parasites and disease are useful precursors to his very brief presentation titled "Varied opinions on the 'elk problem'." In his chapter on reproduction, he implies that the most important limiting factor in the annual increase appears to be the failure of many cows of breeding age to produce calves in the spring. Though granting their due weight as causes of loss he gives natural predators a secondary role in their controlling effects on elk population surpluses. He briefly describes a great number of miscellaneous injuries, accidents, and types of parasitism and disease, and reserves for comprehensive and excellent treatment the subject of necrotic stomatitis, which he feels is the most important agent of mortality in the disease category.

The subject of food habits is presented in 63 pages of documented facts obtained from stomach analyses, direct observation of feeding elks, and examination of unit areas recently grazed by elk. The habit of elk use is described for each plant species and the whole chapter comes alive by the author's use of vivid descriptions of the manner and circumstances of elk grazing and browsing activities. In discussing competition on the range between elk and other species of big game and domestic stock he concludes that the generalized food habit of elk and their versatility in gaining subsistence makes them formidable competitors with other game species, especially with deer on the winter range, and that "all things considered, it must be concluded that domestic stock and elk exert the same type of pressure on the range, which should therefore be stocked accordingly." He has words of caution on the proposal of introducing elk into the interior of Alaska where they might compete extensively with the native caribou for lichens, which food appears indispensable to the latter.

The last three chapters present stimulating discussions on elk populations as units, elk hunting, and elk management. The herd habit, significance of the birth rate, and sex ratios are treated as biological characteristics of the species which must be understood for management. Furthermore, in speaking of "elk management" objectives, he makes the point that management of any species should take into consideration the associated species, both game and non-game, preservation of the vegetative types and the multiple uses of the land. If the reviewer were to choose one chapter from this book as a "must" for wildlife technicians, and sportsmen alike, he would choose the closing one titled "Elk Management." In its 42 pages Murie succinctly covers elk census techniques

and their use, range carrying capacity evaluations, interspecific competition for food, range preservation, artificial fluctuations, artificial feeding, salting as a management tool, predatory animal control, hunting regulations, and elk refuges. He ends with a challenging series of reflections on the problem of maintaining standards, maintaining quality of game animals themselves and the quality of man's enjoyment of them.

This book constitutes a major reference work on American elk for students, professional wildlife men, natural history enthusiasts, and big game hunters. A bibliography of 438 references is provided which in itself is a valuable contribution to the field. It is illustrated by 32 figures of the author's line drawings, 29 photographic plates and a handsome frontispiece in full color by the wildlife artist, Walter A. Weber. Men in the research field will find stimulus in this book for new effort, for Murie, unlike some, makes it clear that he hasn't found "all the answers." His stature as a great naturalist is enlarged by his modesty.—E. L. CHEATUM.

The Elk of North America. By O. J. Murie. Stackpole Co., Harrisburg, Penna., and the Wildlife Management Institute, Wash., D.C. 376 pp., 1951. $6.50.

This monograph on the elk or wapiti has been awaited eagerly by all those interested in the big game of North America. It lives up to the highest expectations held for it.

While the buffalo and barren ground caribou may have elicited more comment from writers of the early period in North America no other animal has assumed as great importance on the modern scene as the elk. Its tremendous tolerance of varied climates and ecologies has taken it from the wettest coastlands to the driest sage brush plains and from the subarctic to the Mexican boundary. Almost everywhere it can occupy a predominant position. It is particularly fortunate and significant that the present study was centered in Wyoming, at the heart of the species range. Here the conditions of life for the animal may well be at their optimum and as such provide an excellent base upon which to begin assembling the details of departure that accompany adaptation to the many environmental extremes the elk meets.

Throughout, the book is an original contribution. The succession of antlers, the development and replacement of teeth, the details of reproduction, enemies and diseases, and the painstaking discussion of food plants, all contain a preponderance of original information along with a critical treatment of the findings of others. A work such as this one is difficult to write; the life history of an animal does not lend itself to meaningful mathematical treatment, and it is always a problem how to present the wealth of variable material available. Dr. Murie has chosen the most satisfying technique of first generalizing and then drawing on carefully chosen incidents to illustrate the point. The result is a monograph with the generalizations required by the average reader along with sufficient factual data to stimulate the interest of the game biologist.

As one familiar with the elk in western Canada it is probably natural that I regret the somewhat sketchy treatment given this northern 20% of the primitive range, where in 27 pages of distributional data the Canadian range is accorded just half a page. In this it is stated that *Cervus c. nelsoni* ranged through Canada from eastern British Columbia eastward to Ontario. This I am sure is just a *lapsus*, as the accompanying map shows the much greater probability that the elk of Manitoba and Saskatchewan were *manitobensis* and those of Ontario the race *canadensis*.

The elk in the Canadian Rockies of Alberta and British Columbia shows some interesting divergencies from the details given by Murie for the more southern latitudes. In the first place their decline in numbers took place suddenly from the ravages of starvation or disease and almost unaided by man. Almost overnight we found ourselves with not more than half a dozen small herds scattered at isolated points over this vast area. The date and details are not clearly known beyond that it happened in the late 1800's.

It is equally interesting to compare the vital statistics of the Canadian Banff and Jasper herds on overstocked ranges with those of the Jackson Hole herd. The two bodies of data are strikingly similar, with pregnancy rates of up to 90%, live calves at heel in June about 50%, and yearlings added to the herd 20% or less, of the number of cows.

I am sure, however, that care should be

exercised in assuming that these figures represent a "normal" situation for elk. They seem to me rather to reflect one aspect of environmental resistance resulting from overcrowding. Just so also does the scarcity of twinning. Contagious abortion has not been found on the Canadian ranges to help explain the very high prenatal losses.

The author's experience on the Wyoming ranges has led him to the conclusion that malnutrition *per se* is not a serious cause of loss to the elk herds. Here necrotic stomatitis was the most destructive agent. Again the Canadian herds present a significantly different condition. Necrotic stomatitis is exceedingly rare in occurrence in elk, but winter ticks, lung-worm, and just uncomplicated starvation account for the largest proportion of the annual losses.

The section on food was of particular interest to this reviewer. While I was surprised to meet my old friends the Douglas fir, Mountain mahogany, False hellebore and Oxeye daisy as Douglasfir, Mountainmahogany, Falsehellebore and Oxeyedaisy and can see little reason or advantage in the resulting amalgam, it was the catholicity of plant use by the elk that appeared most significant. The browsing of lodgepole pine, bush cinquefoil, western hemlock, and Sitka spruce judged against elk behaviour in British Columbia points clearly to a long history of overstocking in the Wyoming and Olympic areas reported on and lends further weight to the abnormality represented in low fetal survivals. The section leaves me wishing that a list had been included of those trees and shrubs refused by elk under the prevailing circumstances.

Many other portions of this thought-provoking book could be singled out for special comment but to me it is in the section on elk management that Dr. Murie clearly shows the breadth and depth of his grasp of the highly complex dynamic aspects of his art. His introductory statements of the objectives of management will be widely quoted, then step by step the author elaborates a philosophy of management most satisfying to this reviewer. The idea of purposeful fluctuations is a new one of great merit under certain ecological conditions. Its application will be limited to climax or long-lived subclimax plant communities and will have little use on the fire type, pioneer, vegetation that makes up much of the present-day range of the Roosevelt elk in British Columbia. There is food for thought and material for experiment in the idea.

Slightly less than a page and a half is devoted to the subject of predatory animal control in elk management, an allotment directly indicating its relative unimportance.

Many interesting and important avenues for further research are brought into relief by this study and it should do much to direct such investigations along potentially productive lines.—I. McT. COWAN, *Department of Zoology, University of British Columbia, Vancouver, B. C.*

American Wildlife and Plants. By Alexander C. Martin, Herbert S. Zim, and Arnold L. Nelson. McGraw-Hill Book Co., N. Y. ix+500 pp. 1951. $7.50.

This is the definitive summary of more than a half-century's study of wildlife food habits in the United States. Because such study is no longer supported through appropriations with the vigor with which it was once encouraged, and for other reasons mentioned below, AMERICAN WILDLIFE AND PLANTS will probably never be duplicated. It should therefore take its place on reference shelves for years to come. Many students have utilized the extensive records that have been amassed, and some sizeable compilations have been made, such as VanDersal's NATIVE WOODY PLANTS OF THE UNITED STATES, Martin and Uhler's FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA, McAtees' WILDFOWL FOOD PLANTS, and Graham's LEGUMES FOR EROSION CONTROL AND WILDLIFE. There has been no publication, however, as comprehensive as the one under review. The authors are associated with the U. S. Fish and Wildlife Service and the book was prepared under the direction of that agency.

The book is a reference volume. It is divided into three parts. The first is introductory and includes a chapter explaining the symbols which are used throughout the work. For each species of plant and animal, symbols indicate the degree of use, season of use, number of specimens examined for each season, and other types of information. While the elaborate sys-

tem of symbols undoubtedly conserves words, the reader will either have to use the book often enough to keep the system in mind or refer back to the detailed instructions in the introduction to understand what is meant by the symbols every time he consults the work.

Part II is a compendium of animals, largely birds and mammals, and the food each is known to eat. Brief notes are given on the animal—its habits, habitat, range. For most species there is a distribution map, and a chart showing the proportion of plant to animal food by seasons. There are general comments on both the animal and plant food, with records of the latter given in detail according to the system of symbols employed. One wonders why there is the detailed presentation of plant foods when animal foods are given only in generalities, even when they compose the bulk of the food consumed throughout the year. The treatment of animals of economic importance is in some instances disappointing, as with the coyote. Members of the Wildlife Society will wonder why Murie's study of the coyote was not cited along with Sperry's. Murie's work received the Society's award as the outstanding paper of 1941, and included an analysis of 5000 coyote droppings.

The third portion of the book is in a sense the reverse of the second. It presents a treatment of plants with comments about them and their use by wildlife. Maps of the United States show distribution of the plants, as is done for the animals in Part II. A unique feature of the book, and one of its highest values, is that here in a single volume can be found distribution maps of the common plants and animals of our country. In this part of the book, as well as in the part on animals, numerous species are illustrated by authoritative drawings, many of the animals done by Weber, the plants by Brainerd. The presence of these vignettes, scattered through the text, does much to add a pleasing appearance to the book. The publishers, in fact, have done a commendable job of attractively presenting the material with which they had to deal.

The wildlife manager is likely to judge this book by the use he can make of it in management. As with other resources, it was at first necessary in America to learn everything we could about the nature and behavior of our wild animals. Thus we gathered a great deal of information about the food of wildlife by observing what it ate and by examination of great numbers of stomachs, crops, and droppings. Such activity has given us a good general knowledge of food habits, now presented in useful fashion in AMERICAN WILDLIFE AND PLANTS. At the same time that the book summarizes what we have learned in the past, it may well pose the question of what remains to be learned in the future. If the wildlife manager is to learn how to produce wildlife, as other resource managers produce other crops of the land, he will need more specific knowledge of food habits than that which is so far available. What is being learned about the relationship between *Lespedeza bicolor* and the bobwhite quail in the Southeast is a case in point. Although the book under review lists many plants that are eaten by the bobwhite, it does not list *L. bicolor*. Yet in many parts of the Atlantic Coastal Plain land owners have found the use of this plant alone to determine the success of quail management. Along with other aspects of management, we need to know the particular plants that will provide a particular animal the food it needs at all seasons of the year so that we can guarantee to increase its numbers. Shotgun methods that only promise more wildlife from miscellaneous "plantings for wildlife food and cover" are no longer justifiable. Such knowledge is sorely needed, but until it becomes available AMERICAN WILDLIFE AND PLANTS stands as our best guide to wildlife food habits in the United States.—EDWARD H. GRAHAM, *U. S. Soil Conservation Service, Washington 25, D. C.*

Ecological Animal Geography. By Richard Hesse, W. C. Allee, and Karl P. Schmidt. Second Edition. John Wiley and Sons, New York. 715 pp. 1951. $9.50.

The appearance of the first edition of this book—a considerably modified version of Hesse's "Tiergeographie"—was an exciting biological event in 1937. In an attempt to demonstrate and to generalize upon the facts and causes of animal distribution, a wealth of fascinating and little-known information was assembled within a single volume which could be repeatedly read with continuing profit. The magnitude of the work was ample excuse for

occasional errors, repetitions, overly broad generalizations, and obscurities of terminology and citation.

Since that time the revisors have continually collected pertinent information in anticipation of the present second American edition. The result is essentially a brand new book, better organized, more accurate and up to date, and with numerous New World examples which should spare students possible frustration stemming from ignorance of the animals under discussion. The new price is an unfortunate consequence of such complete revision and coupled with the somewhat increased length, may deter classroom adoption of the new edition as a means of orienting students in a restricted phase of ecology.

The first of the four main sections of the book covers "The Ecological Foundations of Zoogeography" in nine chapters comprising 178 pages and presents a considerably improved synthesis of material previously scattered. Chapter seven, "Historical Zoogeography," is especially noteworthy as a concise review of an important aspect of the subject. In devoting this first section to laying the foundation for the more specialized sections to follow, the authors have skillfully and simply emphasized the essential concepts and have generally succeeded in doing so in simple, understandable language. However, chapter nine, "Biotopes and Biocoenoses," offers some exceptions, e.g. "Tychocene animals may be of greater importance in the animal community than are the autochthonous eucene forms." (pp. 172–73).

After digesting Part I, the reader should be in a position to proceed to the sections dealing with types of habitats in which he has a special interest. The remaining parts of the book deal successively with the distribution of marine, fresh-water, and terrestrial animals. The plan for each section is to present a synthesis supported by numerous examples of the predominating ecological factors in the particular "biocycle" and then to proceed to the consideration of more special communities. These chapters are well organized so that a worker should quickly be able to locate the discussion of habitats and adaptive characteristics of the animals in, for example, a particular type of woodland or body of water.

The final chapter on "The Effect of Man on the Distribution of Other Animals" stands by itself as a concise undogmatic discussion of important parts of the conservation problem. However, the entire book is important to all persons concerned with the role of animals in conservation. It is of great scope and exceptions to many of the generalizations will occur to the zoologist. Nevertheless, it will be impossible for anyone working with wild animals to read this book without gaining useful knowledge and being stimulated to make new observations in connection with his own work. —LAMONT C. COLE, *Department of Zoology, Cornell University, Ithaca, N. Y.*

The North American Buffalo, by Frank Gilbert Roe. University of Toronto Press. viii+ 957 pp. 1951. $12.00.

The author chooses to call his subject by the popular name buffalo rather than bison. Any objection to this would be sheer pedantry. There is a discussion of the fossil bison, "variants" of the plains bison, climate and topography of the habitat, habits, destructive agencies other than man, discovery by Europeans, former range, numbers, migration, and influence on the Indian's mentality.

Today the only historic subspecies of *Bison bison bison* generally recognized are *B. b. athabascae* Rhoads and *B. b. oregonus* Bailey. The author, among many others, is skeptical of the former existence of *B. b. pennsylvanicus* Shoemaker but offers little support for his opinion. The contemporary literature of taxonomic value shows that the Pennsylvania bison did not differ from that of the plains. (J. Mamm. **25**: 313, 1944).

The literature on the bison is so vast that many years would be required to cover it state by state. No serious attempt seems to have been made to review the literature on the former range that has appeared since the publications of Allen and Hornaday. The following are cases in point. "I am led to doubt the presence of buffalo in California within any historic period. . . ." Their former occurrence in northeastern California has been shown by C. Hart Merriam (J. Mamm. **7**: 211, 1926; *cf.* Vernon Bailey, North Amer. Fauna 55, p. 59, 1936). With respect to Wisconsin, the author's

(p. 223) discussion of Hornaday's paper indicates that he did not see the map accompanying it. Only the western third of Wisconsin is included by Hornaday. It has been shown that the bison ranged in eastern Wisconsin from Lake Winnebago to Milwaukee and southward. (Trans. Wis. Acad. Sci. 30: 117, 1937).

The author states of Michigan (p. 228): "This lack of evidence to establish clearly occupancy of a territory so closely contiguous . . . may, in my view, be reasonably regarded as supporting the hypothesis of their comparatively recent arrival on the eastern side of the Mississippi. . . ." The Museum of Zoology, University of Michigan, has portions of skulls from two counties, and there are records of the occurrence of bison in three other counties of southern Michigan. (W. H. Burt, The Mammals of Michigan, 265, 1946; N. A. Wood, Occ. Papers Mus. Zool., Univ. Mich. 4, p. 3, 1914).

That the bison also ranged into what now constitutes Florida and Alabama (p. 240) is certain. (M. M. Boyd, Science 84: 203, 1936; A. W. Schorger, J. Mamm. 26: 432, 1945). The documents translated by I. A. Leonard (Quivira Soc. Publ. 9, pp. 57, 161, 233; 1939) are most convincing.

There are occasional slips. The reader may infer from "Oubache [Wabash]" (p. 238) that Marest referred to the modern Wabash River. At this time to the French the Oubache was the lower Ohio, and Marest meant that bison were on its banks in southern Illinois. Lewis and Clark did not see three thousand buffaloes on the Mississippi (p. 345) but on the Missouri.

Careful reading of the book shows that Mr. Roe has flayed more authors than the Indians did bison. Occasionally a writer is so fortunate as to escape with a portion of his hide. So many flamboyant statements have been made on the number of bison on the plains, and the extent and regularity of their supposed migrations, that the critical attitude is justifiable. The book is easily the best work on the bison since the classic historical study by Allen. An immense amount of information, fortified by numerous quotations from the literature, has been made available on the most dramatic quadruped that the Americas produced.—A. W. SCHORGER, 168 *N. Prospect Avenue, Madison, Wisc.*

Insect Control By Chemicals. By A. W. A. Brown. John Wiley & Sons, N. Y. 817 pp. 1951. $12.50.

It is refreshing in this day of "bigger and better" pesticides to see a book that gives something more than passing recognition to the out-of-door hazards surrounding insect-control operations. In this book of 11 chapters, the author devotes one full chapter of 60 pages to "Insecticides and the Balance of Animal Populations." In introducing the subject the author comments briefly on the inadequacy of natural agents in controlling important economic pests, and goes on to state: "Hence a weapon is needed over and above the biotic equilibrium and its manipulation. It has been provided by insecticidal chemistry, and it is the role of the economic entomologist to use it intelligently. He must not turn it on himself or his domestic animals, or on those wild animals that provide him with food and recreation. Nor must he slay his own allies in the fight against insect pests; he must consider the insectivorous birds and mammals and the insect predators and parasites. . . . Thus the weapon must be used as a stilleto rather than a scythe."

The chapter on animal populations is in two parts. The first deals with DDT and its effects on wildlife including certain arthropods; the second part gives similar information for other insecticides. A discussion of the interesting and increasingly important phenomenon of acquired resistance to insecticides which is appearing among many susceptible insects concludes the chapter. A list of 202 references cited adds greatly to the value of this portion of the text.

Other information of interest and value to the wildlife biologist will be found in the chapters: Toxicity of Insecticides to Plant Growth; Chemical Control of Insects Affecting Man and Animals; and Toxicity and Hazards to Man and Domestic Animals. The latter chapter is especially well documented with 241 references cited, and the section dealing with DDT toxicity presents succinctly most of the published information on the subject.

The remainder of the text includes a detailed coverage of such subjects as equipment for insecticide application, pharmacology of poisons for insects, aerial application of insecticides,

and the control of insect pests of plants. The book is unique for its thorough consideration of the molecular structure of organic chemicals in relation to their toxicity to insects.—J. P. LINDUSKA, *U. S. Fish and Wildlife Service, Washington* 25, *D. C.*

American Bird Songs. Vol. II. By P. P. Kellogg and A. A. Allen. Comstock Publishing Company, Ithaca, N. Y. Five 12-inch vinylite phonograph records. 1951. $10.50.

On these five new records are presented 51 bird songs recorded in nature by Cornell ornithologists P. P. Kellogg and A. A. Allen. This album, and the earlier one (Vol. I consisted of six 10-inch records, presenting the songs or calls of 72 species of birds) are indispensable in ornithology classes, as an aid in teaching the bird songs. Volume II demonstrates the great strides which have been made in attaining greater fidelity, because the recordings are of an exceedingly high quality throughout. While Volume I had a complete record devoted to the songs and calls of North American game birds, Volume II presents two records featuring birds of lakes and marshes, and this includes some additional species which will be of interest to wildlife students, such as the whistling swan, lesser Canada goose, western and pied-billed grebes, sandhill crane, coot, Wilson's snipe, and Virginia and sora rails. Many of these birds are so seldom seen while calling that the beginner finds it exceedingly difficult to associate calls with the proper species, and the aid which these records give will prove very helpful. To the reviewer the incredibly faithful recording of the "winnowing" of the Wilson's snipe is worth the price of the entire album. —GUSTAV A. SWANSON.

The Birds of Greenland, by Finn Salomonsen. Color plates by Gitz-Johansen. Ejnar Munksgaard, Book Publisher, Copenhagen, Denmark. 1950. 4°. Part 1, 158 pp., 17 full-page color plates. Price Danish kroner 60.

The bird fauna of Denmark's colony Greenland has in the past been treated in various comprehensive publications, most of these in Danish for which reason their contents have been too little known abroad. Dr. Finn Salomonsen, Curator of Birds of the Zoological Museum, University of Copenhagen has therefore met a long felt need by contemplating the issue of this handbook of the birds of Greenland.

A compilation of all the facts collected on the systematics, distribution, migration and life histories of Greenland birds was needed, and it is fortunate and appropriate that this work is published in Danish as well as English, thus widening the general use of the book; on each page one column is written in Danish, the other one in English.

As far as the text is concerned, Dr. Salomonsen's name is a guarantee of scientific correctness and a clear style. Dr. Salomonsen himself has been on scientific bird expeditions to Greenland on several occasions and is also the leader and coordinator of the Greenland bird banding program. The breeding birds are treated in detail; bird visitors to Greenland will be listed only. Results from the recently expanded banding program in Greenland are included where results are known. In this first part of the work the following birds are treated: loons, tube-nosed swimmers, ducks, geese, swans, mergansers and cormorant.

Most of the birds are portrayed on excellent off-set color plates. On each plate only one bird is portrayed in its natural surroundings. Many of these water-color reproductions are excellent, giving a superb impression of the vastness and coloration of the Greenland landscape.

A great many new and interesting facts are presented in this book, and there is no doubt that North American ornithologists will use and appreciate this work. Unfortunately the price of the books is high (due to excellent paper, printing and the many color plates); another matter which is going to complicate the general spread and use of the Birds of Greenland is the somewhat peculiar agreement that only 1850 copies are published and that it is never going to be reprinted!

The Birds of Greenland will be complete in three volumes, totalling 434 double-columned pages plus 52 planches, printed in off-set in six colors. The second part will be issued in the summer of 1951 and the last part late in 1951. —KAJ WESTERSKOV.

Union Bay. (*The Life of a City Marsh*), by Harry W. Higman and Earl J. Larrison. University of Washington Press, Seattle 5, Wash. $4.00.

This is to me a surprising and delightful book. My wife opened it first and her preliminary curiosity led to a one-session reading, clearly indicative of the absorbing nature of its contents. She tried it on the neighbor's 12-year-old daughter who opened it from politeness and five minutes later subsided onto her shoulderblades and lapsed into silence. My own experience with it was no less keen, in fact I am sure it was even greater than theirs; for this is a story told with sufficient vivacity and humor to interest the young and at the same time there is a keenness of perception and an aptness of phrase that makes it possible for the reader to enjoy in proportion to his knowledge.

Starting with the thesis that it is no longer possible to ignore man in any wildlife story, the authors in just over 300 pages take one again and again through this city marsh each time viewing a different facet of its teeming life, each time watching this life break and swirl around human presence like the dark water parting at the canoe prow.

There is good biology aplenty in it too but it is unobtrusive. The simon pure behaviorist may perhaps take exception to the few outbursts of anthropomorphism. These the authors acknowledge and indulge for a purpose and I think generally achieve their aims. In only one chapter, that on the phalarope, did I find it overdone.

They have had untold hours of fun, relaxation, and absorbing interest in the marsh of which they write. If you would relive some of your own most satisfying experiences, if you seek to awaken others to the fascination to be found outdoors, this book will do it.—I. McT. COWAN, *University of British Columbia, Vancouver, B. C.*

Some Aspects of Missouri Quail and Quail Hunting 1938–1948. By Rudolf Bennitt. Missouri Conservation Commission Technical Bulletin No. 2, 51 pp. Illustrated, 1951.

Those concerned with bobwhite quail will be interested in this complete report of Dr. Bennitt's work with whistle counts as population indices, hunter statistics, and sex and age data.

The call index, or average number of birds heard per stop, is shown to be correlated with hunting success. The counts were made for two or three minutes at each of some 19,000 stops during the first hour after sunrise. Corrections were found necessary for temperatures above or below 70–74.5, whistling being reduced more than half by temperatures over 85. The call index was used to make an annual preseason prediction of hunting success, in birds bagged per gun-hour. Hunter reports of success showed an average annual departure from the predicted success of 7.2 percent.

The figures showed highest densities of quail on inferior soils and lowest densities on the best soils.

Collection of more than 51,000 quail wings provided comprehensive sex and age records. Inversity is clearly demonstrated with highest call indices and highest hunting success in years of lowest percentage of young in the population. Those who are working with sex and age data will recognize the great value of having corresponding density indices, such as those for Missouri.

The paper will be very useful in Missouri. Elsewhere, the first question will be whether the method is applicable.

Experience in Texas indicates that our quail populations are much less stable and that whistling is much less persistent than in Missouri. In 1949, using the Bennitt system, but ignorant of the necessary temperature corrections, four biologists in different regions got call index averages of .09 to .17. Obviously, even temperature corrections would not make these figures approach those of Missouri, which ranged from 1.94 to 2.66. Yet Texas hunting success approximates that of Missouri.

Other comparisons, such as the wider range of sex and age ratios in Texas, suggest that southern, or at least southwestern, bobwhites are less stable. In Missouri, the percentage of young in the population ranged from 79.2 to 84.4, young per adult female from 10 to 13, old males per 100 old females from 137.8 to 160.8. In Texas, the percentage of young ranged from 70 to 86, the young per adult female from 5.3 to 17, old males per 100 old females from 112 to 233.

Perhaps this is to be expected of a species as it approaches the periphery of its range. At any rate, the use of whistle counts seems of doubtful value in Texas. That the method is workable in Missouri is abundantly demonstrated by Dr. Bennitt's very thorough study. Certainly no better approach to the problem of predicting hunting success has been published. Every quail state will want to try the method and many will find it useful.—DANIEL W. LAY, *Texas Game and Fish Commission, Buna, Texas.*

Algae of the Western Great Lakes Area. By G. W. Prescott. Cranbrook Institute of Science, Bloomfield Hills, Michigan. Bull. No. 31. xiii+946 pp. illus. 1951. $10.50.

The author has succeeded to a high degree in meeting the need for a handbook which would be serviceable to conservationists, aquatic biologists, investigators and students who are interested in the taxonomy, distribution and ecological relationships of the algae. The volume includes about 1200 species representing all groups of freshwater algae exclusive of desmids and diatoms known from Michigan and Wisconsin.

Planktonic as well as attached forms of open water lakes are included. Detailed consideration of the many kinds of algae thriving in submerged weed beds, margins of lakes, shallow ponds, marshes and sphagnum bogs has allowed special emphasis to be devoted to the *periphyton*, that large and biologically important assemblage of algae that grow attached to the stems and leaves of the larger aquatic plants.

While the algae covered are those known from Michigan and Wisconsin many of these have a much wider distribution so that the book will be useful throughout North America especially to anyone interested in the productivity of a lake or pond which would involve the role of algae in the food chain of aquatic animals.

An analytical key is provided to facilitate the determination of any alga to the genus. Keys are also provided for the separation of species in each genus. Descriptions, distribution data and habitat notes are provided for nearly all species.

One-hundred-thirty-six pages of clear-cut line drawings illustrate the diagnostic features of each species. A 49 page bibliography includes a very complete reference list of works on the algae of the area. A glossary of terms relating to freshwater algae will be of special interest to aquatic biologists in applied fields. —W. C. MUENSCHER, *Department of Botany, Cornell University, Ithaca, N. Y.*

Iowa Fish and Fishing, by James R. Harlan and Everett B. Speaker. Iowa State Conservation Commission, Des Moines. iv+237 pp., figs. 1–9, plates 1–22 (9 in color), 1951, 1st ed., April 20, 2nd ed. Aug. 25, $2.00.

An attractive book written primarily for the anglers of Iowa but which is a must for midwestern fishery biologists, for ichthyologists, and a worthy and inexpensive addition to the libraries of students of wildlife and natural history. The Iowa Conservation Commission is to be congratulated for publishing this beautifully illustrated book. Similar volumes are badly needed for other areas and the immediate large sale and financial success of this book should convince administrators of the value of such regional works. Everett B. Speaker informed the reviewer that the first edition of 10,000 copies was virtually exhausted in four months at which time a second edition (not seen by the reviewer) of 9,750 copies was issued. Approximately 20,000 copies of the colored plates were originally printed at a cost, including the art work, of $9,155. A third edition is not contemplated at this time.

An outstanding feature are the colored paintings, apparently from life, of 24 game and pan fishes by Maynard F. Reese. The technical reproduction of the 9 colored plates on fine paper is a task of skillful workmanship seldom seen in recent publications. Those reproduced in color are small and largemouth bass and 8 others of the sunfish family, white bass, yellow bass, 3 catfishes, 3 trouts, yellow perch, eastern sauger, walleye, northern pike, mooneye, and freshwater sheepshead. The catfish plate is especially fine and lifelike. The second dorsal fin of the smallmouth bass is considerably more pointed than that of several adult specimens which the writer has observed in aquaria recently and it seems that the specimen which

was painted was somewhat abnormal. In addition there is a black and white plate of 5 primitive fishes from Forbes and Richardson's Fishes of Illinois and sixty photographs of fishes arranged on 12 plates. These photographic reproductions are inferior, partly due to the considerable reduction in size. This is especially regrettable since the space available on the plates would have permitted reproductions of considerably greater length. The second figure on Plate 14 was inadvertently mislabeled hornyhead chub, *Hybopsis biguttata*, whereas it is a northern creek chub, *Semotilus atromaculatus atromaculatus*.

A valuable section of the book from the standpoint of permanent value to ichthyologists and fishery biologists, is the last (52 pages), which was written by Reeve M. Bailey and entitled "A Check List of the Fishes of Iowa, with Keys for Identification." The well illustrated keys are a refinement of mimeographed keys developed during his tenure at Iowa State College and are an accurate guide to the identification of the 137 species and subspecies of fishes known with certainty from Iowa. Dr. Bailey has also announced important taxonomic decisions and nomenclatorial changes, and has carried out his recently recommended (unpublished) changes for delimitation of genera of some North American freshwater fishes. Some 38 bibliographic references were listed for this section.

The remainder of the book (184 pages) was written for the fisherman and with excellent results. There is a short introduction to Iowa's fishing waters, under the headings natural lakes, rivers, oxbow lakes, trout streams, artificial lakes, and reservoirs. After an introductory statement which deals with the structure and physiology of fishes in general, the various family groups are considered. For most species the common name, scientific name, other names, Iowa status, description, food habits, life history, and angling methods are treated. Some original research is included in some sections on food habits and life history, and in most cases the latest and most pertinent literature (129 references) for Iowa and adjacent areas has been summarized.

Of particular interest to Iowa anglers is the rather extensive chapter on angling. The various experts, mostly anglers with biological training, have contributed sections on fishing for channel catfish, bullheads, largemouth and smallmouth bass, carp, trout, walleye and panfishes such as the crappie, bluegill and yellow perch.

An illustrated chapter on common fish foods gives pertinent information regarding the forms most often seen by fishermen. The figure on page 146 labeled Predaceous Diving Beetle represents the Giant Water Bug, *Benacus* or *Lethocerus*, and that labeled Giant Water Bug on page 144 (carrying eggs on the back) is a water bug, *Belostoma*. This book should further stimulate wide interest in an extended study of the fishes of Iowa.—EDWARD C. RANEY, *Department of Conservation, Cornell University, Ithaca, New York.*

Name That Animal, by Ernest C. Driver. The Kraushar Press, Northampton, Mass., 1–558 pp., many figures (unnumbered), 2nd edition, 1950.

An elementary guide to the identification of common land and freshwater animals of the United States with special reference to the area east of the Rockies. The first half of the book consists of an introduction giving general collecting instructions and keys to various groups of animals, and then considers under separate chapters the following: protozoa, moss-like and jelly-like animals, rotifers and gastrotricha, worm-like and leech-like animals, mollusks and arthropods. Many of the animals in the above chapters are keyed only to genera. The treatment of insects is very general with a key to orders. The sections on freshwater fishes, salamanders, frogs and toads, lizards, snakes, turtles and mammals are somewhat more complete, with keys to species and sometimes to subspecies. The short section on birds characterizes briefly the orders and families and is of little value. Two short chapters on Eggs and Tracks give a guide to a few of the most obvious that may be encountered. Each chapter is followed by a list of general references.

The author makes no claim for completeness in any of the keys to the various groups but rather hopes that the utilization of the book will serve to stir up interest among beginning zoology students. Indeed accurate determination by the use of these keys is impossible in

any but a very small minority of species and it is of little value to the worker in the wildlife field. Since scientific names and compiled ranges have been given especially in the treatment of the cold-blooded vertebrates it has been cited in synonymies by some taxonomists. There appears to have been little attempt to bring the taxonomy, nomenclature, and other data up to date beyond the latest check list or other prominent reference work in the special field. The line drawings with which it is profusely illustrated are poor and in many cases are not diagnostic.—EDWARD C. RANEY, *Department of Conservation, Cornell University, Ithaca, New York.*

A Guide to Bird Finding East of the Mississippi. By Olin Sewall Pettingill, Jr. Oxford University Press, New York. 659 pp. illus. 1951. $5.00.

The wildlifer who does any traveling will find this volume, and its counterpart for the western states which is soon to be published, invaluable. On any extended automobile trip, or on the occasion of being stationed in a new area, every wildlifer has felt the need of a guide like this. Each state is the subject of a separate chapter which describes concisely the more important places where birds may be found in season, and the more interesting species to be found. The locations of bird collections, colleges teaching ornithology, wildlife refuges, state and national parks with particular wildlife interests, and contact points for bird clubs and ornithological societies are all indicated. Seventy-two attractive pen and ink drawings by George M. Sutton depict characteristic birds in each region.

The tremendous task of compiling this bird students' Baedecker has taken several years, and required the cooperation of hundreds of authorities who contributed data about the places they knew best. The accounts are naturally brief (averaging about 24 pages per state), but for those regions with which the reviewer is familiar, they are certainly inclusive enough to be exceedingly useful. Publisher and author are to be congratulated upon having rendered an outstanding service to American bird students. The volume will make their travels from now on more profitable than ever before.—GUSTAV A. SWANSON.

RECENT PUBLICATIONS

Chronic Toxicity of Some New Insecticides to Bob-White Quail. By J. P. Linduska and P. F. Springer. Special Scientific Report: Wildlife No. 9. U. S. Fish and Wildlife Service, Washington. 11 pp. Processed. (Undated)

Effects of DDT on Saltmarsh Wildlife, 1949. By P. F. Springer and J. R. Webster. Special Scientific Report: Wildlife No. 10. U. S. Fish and Wildlife Service, Washington. 24 pp. Processed. (Undated)

The Barren-Ground Caribou. By A. W. F. Banfield. Canada Department of Resources and Development, Ottawa. 52 pp. Processed. 1951.

Stalking Birds With Color Camera. By Arthur A. Allen. National Geographic Society, Washington. 328 pp. illus. 1951. $7.50.

A presentation of 331 illustrations in natural color, showing 266 species of North American birds, plus many black and white illustrations in addition, with descriptive text. The author is responsible for 264 of the color illustrations, but altogether 20 of the leading bird photographers of today are represented. Much of the text and most of the illustrations have already appeared in National Geographic Magazine, but 72 new color plates never before published are included. The book makes an ideal gift for those interested in wildlife, and is a "must" for the bird photographer. Waterfowl, upland game birds, and the raptors are very well represented in the photographs, which are of the very highest quality.

Mexican Birds. First Impressions based upon an ornithological expedition to Tamaulipas, Nuevo Leon, and Coahuila with an appendix briefly describing all Mexican birds. By

George M. Sutton. University of Oklahoma Press, Norman. 282 pp. illus. 1951. $10.00.

Any wildlife student, whether his interest is birds in general, wildlife ecology, or the game species primarily, will be interested in perusing this book preparatory to making a trip to Mexico. Although not designed as a guide to Mexican birds, the book does present in Dr. Sutton's fascinating prose such vivid descriptions of the experiences a naturalist is likely to have in Mexico that it should prove most useful to the increasing number of persons planning travels in that direction. The book is illustrated with 16 colored plates and 63 pen-and-ink drawings by the author.

Wildlife in Color. By Roger Tory Peterson. Houghton Mifflin Company, Boston. 191 pp. illus. 1951. $3.00.

With the cooperation and sponsorship of the National Wildlife Federation, Roger Peterson presents a beautiful little book illustrated with 435 colored illustrations of birds, mammals, fishes, flowers, trees, insects, and a few reptiles and amphibians which have appeared between 1939 and 1951 in the well known wildlife stamp series, published by the Federation. Eighteen of the leading wildlife artists have examples of their work represented, and the excellent descriptive text by Peterson is arranged by ecological communities as far as possible. A particularly excellent gift volume.

Birds of Newfoundland. By Harold S. Peters and Thomas D. Burleigh. Houghton Mifflin Company, Boston. 431 pp. illus. 1951. $6.00.

Latest in the series of American regional bird books, this handsome volume illustrated with 32 full color plates showing 153 species painted by Roger Tory Peterson will prove of wide interest. Only financial sponsorship by the Department of Natural Resources of the Province of Newfoundland could have permitted the release of a work of this character at this price.

Natural History and Economic Importance of the Muskrat in the Athabasca-Peace Delta, Wood Buffalo Park. By W. A. Fuller. Canadian Wildlife Service, National Parks Branch, Department of Resources and Development, Ottawa. Wildlife Management Bulletin, Series 1, No. 2. 80 pp. illus. Processed. March, 1951.

Waterfowl and Related Investigations in the Peace Athabasca Delta Region of Alberta, 1949. By J. Dewey Soper. Canadian Wildlife Service, National Parks Branch, Department of Resources and Development, Ottawa. Wildlife Management Bulletin, Series 2, No. 2. 63 pp. illus. Processed. May, 1951.

CORRECTION

AERIAL CENSUS OF NORTHERN BISON

In comparing the results of the 1951 census of Northern Bison with those obtained in 1949 (Jour. Wildl. Mgt., **14**: 445–51) an error in addition of numbers in field records was discovered. The following changes are therefore required in the text:

Page 448 column 2 line 12:
for 3,263 read 2,868.
line 31:
for 2,534 read 2,139.
line 33:
for 10,865 read 9,285.

Page 449 column 2 line 2:
for 12,000 read 10,000.

Page 450 column 2 line 23:
for 15,000 read 12,500.
line 27:
for "between 12,000 and 15,000" read "between 10,000 and 12,500."

Similar changes are required in the summary, under paragraph (2).—W. A. FULLER, *Canadian Wildlife Service, Fort Smith, N.W.T., Canada.*

BRIEFER ARTICLES

USE OF ITALIAN RYE GRASS AS A MEANS OF ATTRACTING WATERFOWL

The use of annual Italian Rye Grass, *Lolium multiflorum*, as a supplementary means for attracting waterfowl was begun at the Wheeler National Wildlife Refuge in 1946. It has proven of definite value, and its use should be applicable to other areas.

Wheeler, a wintering refuge supporting a fairly high population of ducks, coots, and Canada, blue and snow geese, is located in the Tennessee Valley of north Alabama, on a part of the backwaters of the Tennessee Valley Authority's Wheeler Dam. Normally, the reservoir is full throughout spring and early summer. A draw-down for flood control begins in late summer, or early fall, and continues until midwinter. Throughout the time when concentrations of waterfowl are present, the remaining water area is surrounded by thousands of acres of barren mud flat. The draw-down comes too late for any worthwhile vegetation to establish itself on any but the highest elevations and too late to allow the planting of these flats to seed-producing crops. The necessity for making this expanse of bare mud flat more attractive to waterfowl was recognized early in the history of the refuge; and plantings of wheat, oats, rye, and barley were tried. Heavy rains during the winter invariably raise the level of the reservoir several feet for short periods, and these rises drowned the small grain plantings.

The senior author, searching for a plant to withstand flooding, began experimental plantings of rye grass in 1946. These plantings withstood several floodings, some for a period of two weeks, throughout the winter of 1946–47 and were well used by waterfowl. Based on this experiment, large-scale plantings were made in the fall of 1947 and have been continued each fall since.

These plantings have been used extensively by waterfowl. Canada, snow and blue geese in numbers ranging from small flocks to several thousand birds have been observed to feed regularly upon well-located plantings. Utilization is sometimes heavy enough to seriously damage the stands. When partially-flooded with a few inches of water, dabbler ducks use it in the same manner as they use aquatics. Baldpates, mallards, black ducks and coots have been observed feeding on plantings more than 100 feet from water. Use of the rye grass continues from early fall throughout the winter. When it is planted in desirable locations on Wheeler Refuge birds tend to use rye grass in preference to other green browse, and during periods of the day when they would not normally be feeding on other foods.

At Wheeler, rainfall is heavy, soil is fertile, and the winters are usually mild. Experiments have shown that rye grass can be successfully planted from July until January. However, early plantings are sometimes sun-killed and, if not, usually become too coarse and rank for good browse by the time wintering birds arrive in numbers. Plantings made too late do not put on enough growth to be of much value for wintering birds. In north Alabama, the month of September and the first half of October are considered best for planting.

In selecting planting sites, preference is given to the higher mud flats since these will be flooded less frequently and for shorter periods. Such sites should be located in places not subject to disturbance and near locations used by concentrations of waterfowl. Mud flat islands or "hogbacks" are often ideal. While the normal rate of seeding on uplands is only 25 pounds per acre, 50 pounds per acre should be used for mud flat planting. This amount can be reduced to 25 or 30 pounds if flats are hard enough to permit light disking. Care should be used to prevent seed from falling in water, since these are largely wasted. In general, it is best to plant on freshly exposed flats. Windless weather, just prior to a rain, is ideal.

Seed can be sown by a planting crew, using rotary type seeders, or by airplane. Both methods have certain advantages. With hand seeding, based on a wage rate of $1.00 per hour, the cost of planting will vary from $1.50 to $2.50 per acre. Hand seeding generally results in better coverage and less wasting of seed. Airplane seeding is preferred where the time factor is important, where labor is lacking or overly costly or where inaccessible areas are involved.

The cost of rye grass seed, bought in bulk, varies, but is usually 10–13 cents per pound. Where game managers have upland agricultural fields available, this cost can be materially reduced by raising the seed supply. Rye grass can be grown in those parts of the United States where commercial small grain growing is possible. Seed patches can be placed on land too low and wet for oats or wheat. Land preparation, fertilizing and time of combining approximate that for winter small grains in the same locality. The seed are not difficult to combine, and yields of from 300 to 500 pounds per acre can be expected. For efficient planting, seed must be cleaned.

At Wheeler Refuge, as a browse, rye grass ranks closely and is sometimes preferred over the winter small grains. Birds seem to show a slight preference for it, due probably to its greater degree of succulence. Its greatest advantage lies in its ability to withstand flooding and silting. Stands covered by winter floods for two or three week periods and subject to a fairly heavy deposit of silt, show only minor damage. This property permits establishment of rye grass on barren mud flats where no other plant growth is possible. It enables game managers to convert areas that are useless in their present state into green pastures that will attract concentrations of waterfowl.—LAWRENCE S. GIVENS and THOMAS Z. ATKESON, *U. S. Fish and Wildlife Service, Glenn Building, Atlanta 3, Georgia.*

Accepted for publication Jan. 23, 1951.

A METHOD FOR AUTOPSYING A MOURNING DOVE KILL

The sex, age, and breeding status of birds shot during the hunting season are commonly recorded in dove management studies.

An external inspection of birds bagged during the hunters trip in the field will provide adult-juvenile ratios, and plumage coloration and head markings will aid in determining the sex ratio of adults. However, learning the status of the crop gland development would require partial dressing.

A method initiated by the author and used in the Barrington, Illinois, region during the 1949–50 season, while engaged in a mourning dove study, has proven successful in gathering complete autopsy data on this species with a minimum amount of field work. The reason for the bag autopsy was explained to the hunters and the importance of their cooperation was stressed. The essence of the plan is that the hunter, for his cooperation, receives a bird dressed and ready for cooking in exchange for one shot in the field. The wives, who are generally elected to dress the kill, encouraged their husbands to cooperate, for obvious reasons.

The hunter records the time, date, and type of habitat where the doves are killed. At the close of each hunting trip he telephones that he has birds to be picked up, or delivers them to the investigator. A well organized production line must be in operation to facilitate the handling of the birds expeditiously especially during the peak-kill period which is usually the first week of the season. Each bird is tagged with a number which corresponds to a mimeographed file card, then autopsied. If anything unusual is observed, the investigator can lay the bird aside to examine it more thoroughly later, after which it is washed, frozen, and returned to the hunter the next day. This method has furnished an undisputable record of the status of the birds comprising the hunters' kill in this area.—C. W. KOSSACK, *Barrington, Illinois.*

Accepted for publication Dec. 7, 1950.

FURTHER NOTES ON AGE DETERMINATION IN JUVENILE BOBWHITE QUAILS

In our earlier paper (Amer. Midl. Nat. 30(3): 774–872, 1943), the progress of the post-juvenile molt and the growth of first winter primary and secondary wing feathers was correlated with age in groups of captive bobwhite quails (*Colinus virginianus*).

Recently, Thompson and Taber (Jour. Wildl. Mgt. 12: 14–19, 1948) used some of these data to formulate a reference table for determining the dates of laying, incubating and hatching from bobwhites collected during their post-juvenile molt. Recognizing variation in the rates of molts between individuals of the same age, they hoped only to determine the age of a bird by our methods within one week plus or minus of its true age. Their "tolerance limit" seems a sensible one and is supported by the following additional information based on data collected from carefully measured growing primary feathers during our 1943 study:

Known quail ages (days)	Number specimens	Maximum error (days)	Standard deviation (days)
45	10	4	1.32
56	19	4	1.84
70	35	7	3.89
84	32	13	6.18
98	20	13	7.77
112	20	9	5.68
126	20	8	4.63

The maximum and standard deviations were computed from the ages indicated for each specimen by the length of the shortest growing primary possessed in common by all specimens in the age group. Analyses revealed no statistical advantages in averaging the ages indicated by the several growing feathers. Whether the same degree of variation normally occurs in wild populations is unknown. Assuming normally distributed measurements in each age class, these data indicate that usually the true ages of a large majority of specimens can be expected to fall within the one-week-either-way tolerance limits used by Thompson and Taber where detailed measurements of the growing feathers are considered. Even such modest accuracy may not prevail, however, where only observations of the numbers of replaced feathers are considered and more exact measurements of their lengths are overlooked.

It is true that in many wildlife studies of an extensive nature extreme accuracy is not vital. Wing collections enabling the determination of even the month in which peak production of young birds occurred often are very helpful. Yet the greater the accuracy attained, the greater the possible utility of the results. Until the replacement of primary 7, the ages of collected birds in weeks can be fairly accurately determined simply by adding three to the number of the shortest growing first-winter primary (counting from the axial secondary outward). Multiplying by seven yields ages in days. (This system apparently is applicable as a rule-of-thumb in age determination also in ring-necked pheasants, Hungarian partridges and possibly other gallinaceous species.) When the more distal primaries are molted in bobwhites, however, greater accuracy in age determination is needed. Particularly, the nearly month-long interval between the shedding of primaries 7 and 8, the similarly long 49-day growth period of primary 8, make more detailed study of birds of the 74 to 150-day old ages highly desirable if the one-week-either-way standard is to be approached. This period is 60 percent of the time during which the developing wing molt of 28 to 150-day old quail can be studied and these older birds will usually form a majority of specimens collected during fall open seasons.

Interpolations of the growth of primaries, particularly of the outer post-juvenile ones, are rendered somewhat difficult by the fact that about the first three-fourths of their growth is accomplished during the first half of their growing periods. To assist in the more accurate estimation of age in young quail without the necessity of referring to our earlier more detailed report, therefore, the following table is presented:

AVERAGE AGES IN DAYS FOR BOBWHITE QUAILS AS INDICATED BY WINGS IN VARIOUS STAGES OF POST-JUVENILE MOLT

Primary No.	I	II	III	IV	V	VI	VII	VIII
Dropped	28	35	42	47	54	62	74	101
1/4 grown	33	42	47	53	60	68	83	111
1/2 grown	41	47	51	57	65	74	93	119
3/4 grown	45	52	56	62	73	82	105	127
Fully grown	56	58	62	73	85	103	124	150

Where the use of more detailed measurements seems justifiable, the tables of our earlier paper may be preferable.—GEORGE A. PETRIDES, *Dept. of Fisheries and Wildlife, Michigan State College, East Lansing, Michigan* and RALPH B. NESTLER, *Office of Experiment Stations, U.S. Dept. of Agriculture, Washington, D. C.*

FAILURE OF PLACENTAL SCARS TO REVEAL BREEDING HISTORY IN MINK

The need of game managers for means of measuring the annual productivity of every species harvested prompted this attempt to read the breeding history of mink from counts of placental scars on the uterus. A definite relationship between number of young born to a female and the actual number of placental scars visible on the uterus during the ensuing season of harvest has been established for very few species. This stems from the difficulty in capturing females months after they have produced known numbers of young. This is especially true of the mustelids, which produce most of our "fine" fur.

Through the kind cooperation of Mr. Wallace Snyder of Lynwood Fur Farms, Tibbetts, Missouri adult female mink which had produced a known number of young, not only the preceding spring but for previous years as well, were tagged through the tongue with standard ear tags as they were taken from the killing chamber for pelting. Subsequent examination of the uteri, made both on the day of death for some carcasses and several days later for others, failed to reveal any relationship between number of visible placental scars and number of young that had been produced. Uteri were examined *in situ*, by transmitted light over an illuminated opal glass plate after removal, and again after being split longitudinally so that the inner surface could be viewed. Only in a few females were distinctly pigmented scars found. Failure of the method was entirely due to the fact that the scars had nearly all been resorbed before the animals were pelted in December. A second attempt was made the following year with mutant mink of several color phases but the same results were obtained. Among a total of one hundred females known to have produced young the previous spring only eight showed any remaining placental scars. Errington (*in litt.*) informs me that he had the same disappointing results from examining carcasses of wild mink.

To determine whether age groups could be distinguished by examination of the reproductive tract, fifty-five additional females, barren the previous spring but known to have produced young in preceding years, were autopsied along with twenty juvenile females. Neither the length, width, nor appearance of the uterus or vagina proved a criterion of age or breeding success.

These negative results are reported here only in the hope that someone else may be spared fruitless repetition.—WM. H. ELDER, *Missouri Cooperative Wildlife Research Unit, Columbia, Missouri.*

Accepted for publication March 1, 1951.

TREATMENT OF A SICK MOOSE WITH COBALTOUS CHLORIDE

The following case history refers to one adult female moose (*Alces americana*).

Aug. 28, 1950:—The moose was taken into captivity today. She was driven into a building as easily as a tame domestic animal.

Aug. 28:—No food or water has been taken since capture, and the moose is lethargic, emaciated and weak. Eyesight is poor; the left eyelid reacts to motion of a hand at four inches distance; the sight of the right eye is slightly stronger according to this test. The front legs appear to be weak and respiration is by short noisy breaths. The first dose was given at four p.m. The animal was lying down at the time. Her head had to be elevated manually so that she could be drenched. General appearance and condition was such that she was not expected to live through the night.

Aug. 29:—Moose stands more alert and "compact." More movement of the ears was noted. Browsed without persuasion. By evening the quality of the excreta had changed from small

black pellets to larger brown pellets, more glossy and typical of a moose at this time of year.

Aug. 30:—Eats well and drinks water with relish. Eyesight much improved and breathing has become more easy and natural. Animal is much more alert to sound and movement, and will now take a wide variety of browse.

Sept. 1:—Moose shows slight signs of wildness. Does not take drench with previous docility.

Sept. 2:—Excreta has softened and become more amorphous.

Sept. 4:—This is the seventh day of treatment. Doses will be discontinued. Symptoms are no longer evident. The animal appears normal except for rough pelage (the summer coat is now shedding freely), emaciation, and lack of fear of man. Ear tags were placed in both ears.

Sept. 4–13:—General improvement continues. Food consists of any available hardwood twigs, herbaceous plants, and some conifer browse. Water is taken freely. There are some signs of gloss appearing on the pelage, and weight is increasing rapidly.

Sept. 13:—Moose stands tense and nervous. She was released today. She browsed hungrily, and when scared, ran with the typical rocking gait of her species.

Nov. 28:—(Date is approximate—this is a reported observation, believed accurate); Moose was observed crossing a road in front of an automobile at night. She was identified by the metal ear tags and was described as being "in fine shape, and very active."

The dose referred to in the above notes consisted of Cobaltous Chloride ($CoCl_2.6H_2O$); ¼ oz. was dissolved in 32 fl. oz. of water. One fluid ounce of the solution was administered in the form of a drench, further diluted, once a day. The author suspects that this was an overdose; future trials will be made with one fl. oz. per day of a solution of one gm. in 32 fl. oz. of water.

It is considered unlikely that the treatment used would affect secondary disease organisms, or parasites. Ticks were not present. The possibility that the primary cause of "moose sickness" has been diagnosed and removed in one animal is considered strong enough to suggest repetition of the attempt whenever and wherever a suitable subject becomes available.

The treatment described is easily administered. Difficulty is encountered in obtaining subjects in that short-lived stage of the abnormality following loss of fear of man and loss of physical ability to resist treatment, yet preceding death. This period often lasts less than a week, accompanied as it usually is by cessation of intake of both food and water.

It is intended that the Nova Scotia investigations be reported in detail at a later date. That report will present the reasoning and evidence which led to the trial of cobalt; comparison of the geographic distribution of "moose sickness" and cobalt deficiency in the agricultural soils of eastern North America, together with a comparison of the notes presented above with similar results obtained in the treatment of cattle for a deficiency of this mineral has led to the belief that these notes should be released at this time.—D. A. BENSON, *Department of Lands and Forests, Province of Nova Scotia.*

Accepted for publication March 23, 1951.

THE USE OF TRANSMISSION SPECTRA AND CRYSTALLOGRAPHY OF HEMOGLOBIN IN LAW ENFORCEMENT[1]

In a recent law violation case involving the illegal killing of elk, the evidence presented to the courts by the State of Wyoming consisted of a blood stained rag and a piece of canvas which were confiscated from the accused. On one rag there were numerous hairs attached. The techniques used to show these blood stains and hairs were those of elk are described.

IDENTIFICATION OF HAIR

Hair was collected from a jack rabbit, mule deer, and elk for use as a basis for comparison. In collecting the deer and elk hair, samples were taken from the neck, back, flank, rump, and brisket. The hairs were imbedded in celloidin, sectioned, and drawings made with the camera lucida. By comparing the cellular

structure, size and length of the unknown hairs with the hairs of rabbit, deer and known elk, the hair found on the cloth was positively identified as elk.

The identification of hair from the various animals species is difficult, but if they are studied carefully, a conclusion can usually be reached as to the identity of the animal species from which the hair came. The use of identification of hair in law enforcement does have its place. It would need to be used, however, in conjunction with other evidence.

SPECTROSCOPIC EXAMINATION

The blood stains were removed from the rag and canvas by soaking in about 25 cc. of a buffer solution of pH 7.4. When a sufficient amount had gone into solution, as noted by its deep red color, the sample was centrifuged to throw down the debris. In order that both known and unknown solutions would give approximately the same percent transmission values at a given wave length, all samples were placed in a photoelectric colorimeter and, with the use of a green filter, were adjusted by dilution to give a percent transmission of 18. The Beckman Spectrophotometer Model DU was used in determining the transmission spectra of the samples, and readings were taken on each wave length on the scale. The transmission spectra were recorded rather than the absorption spectra since it was assumed that percent transmission would be more easily understood by the layman. These readings are not included here but may be found in Federal Aid to Wildlife Restoration, Quarterly Report Vol. 3, No. 4, Wyoming, July 15, 1950.

The following samples of blood were used as controls: Elk (2) dried and fresh; Jack Rabbit (3) dried and fresh; White Tailed Deer (1) dried; Domestic Cow (2) fresh; Poisoned Dog (1) fresh. Transmission curves are given for fresh blood of rabbit and elk and dried blood of rabbit, elk, and white tailed deer.

Figure 1 shows a comparison of the transmission curves of fresh whole blood of elk and jack rabbit. The curves are almost identical through the wave length scale. However, there is one slight difference. It will be noted that in the vicinity of the wave length at 500 millimicrons the elk blood as indicated by the solid line tended to flatten, while that of the rabbit formed a peak. These differences in percent transmission probably do not represent hemoglobin, and there may be certain constituents of whole blood of elk which may absorb light at this particular wave length.

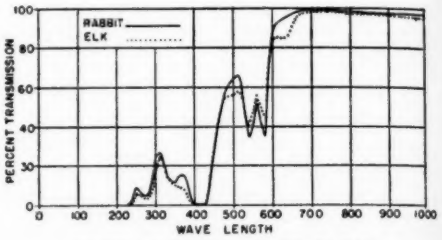

FIGURE 1 TRANSMISSION CURVE FOR FRESH BLOOD OF RABBIT AND ELK

It is unlikely that fresh blood would be presented as evidence in a case of illegal killing of game, and since the materials submitted were dried stains on canvas, it was advisable to determine the transmission curves on several samples of dried blood. The curves as shown in Figure 2 are the results using dried elk, jack rabbit, and white tailed deer blood. The component of fresh blood, in which there is a slight difference between rabbit and elk, disappears on drying, and any difference, no matter how slight, cannot be demonstrated. From the work done so far, there is no means of detecting variations in the transmission curves of dried blood of different species.

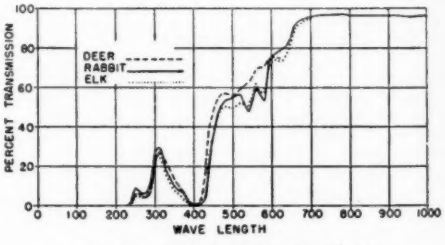

FIGURE 2. TRANSMISSION CURVE FOR DRIED BLOOD OF DEER, RABBIT AND ELK

CRYSTALLOGRAPHY OF HEMOGLOBIN

From the extensive investigations of Reichert and Brown (Reichert, Edward Tyson, and Amos Peaslee Brown, The Differentiation and Specificity of Corresponding Proteins and other Vital Substances in Relation to Bio-

[1] Contribution from Federal Aid in Wildlife Restoration Act Project 33-R, Wyoming.

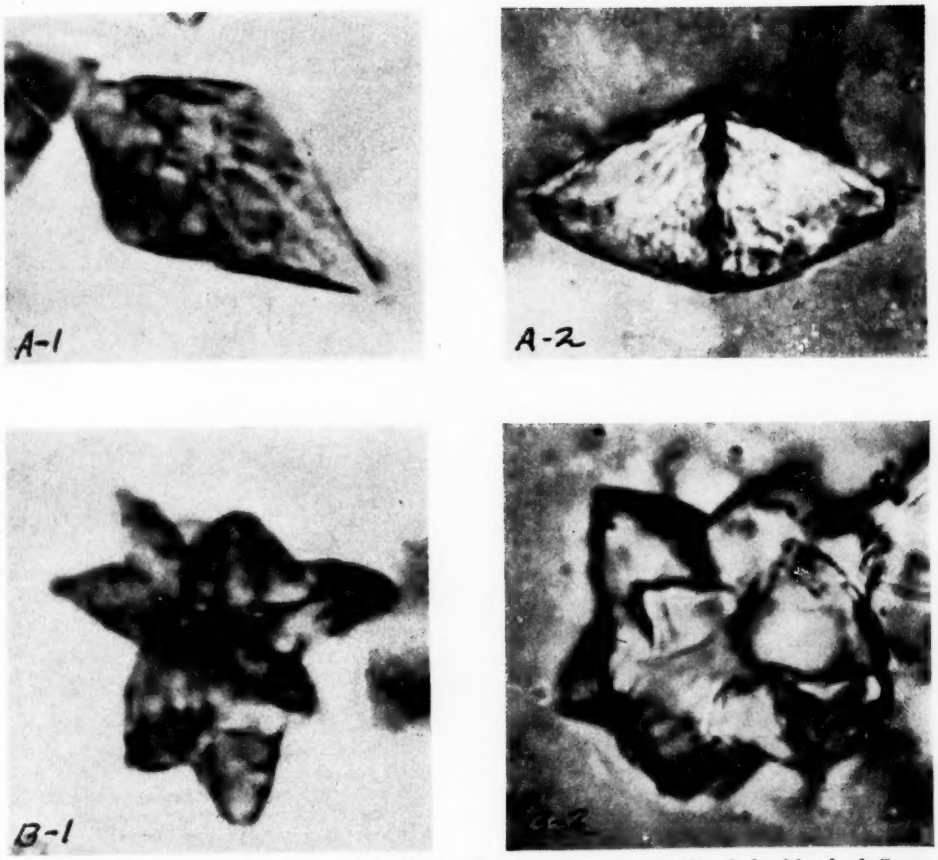

PLATE 3. Photomicrographs of crystals obtained from a known sample of the blood of *Cervus canadensis*, and crystals obtained from blood stains on a cloth. Crystals A-1 and B-1 are from wapiti hemoglobin, whereas, A-2 and B-2 are from the unknown stain. These crystals are much alike and are as described in the work of Reichert and Brown, 1909.

PLATE 4A. (½ reduction) Bearded wheat taken from the stacks where the deer were feeding.

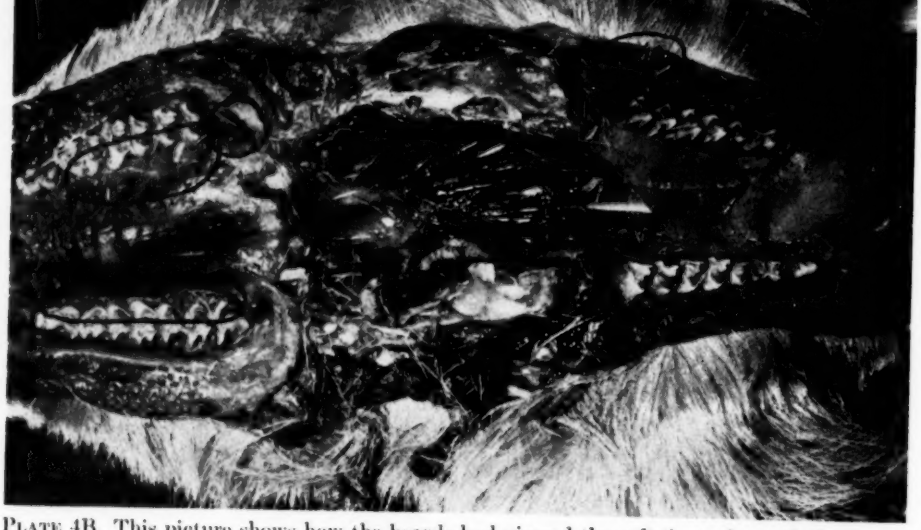

PLATE 4B. This picture shows how the beards had pierced the soft tissues beneath the tongue and in the vestibule. They were also packed between the labial surface of the teeth and the gums.

logical Classification and Organic Evolution: The Crystallography of Hemoglobins. Washington, D. C.: Carnegie Institute of Washington Publication No. 116, 1909.), it is shown that the crystallography of the hemoglobins of different animals is not the same. Hemoglobin from all species studied could be crystallized, usually as oxyhemoglobin, but the ease of crystallization and shape and size of the crystals varied between different animals.

Blood was laked with ether and a small amount of oxalate added. The materials was then centrifuged, and a few drops of the clear solution were placed on slides. A cover glass was applied and the slides placed in the refrigerator. Crystallization usually occurred in 24 hours. Photographs were then taken of the crystals.

By determining the size and shape of the crystals it was shown that the stains on the canvas were those of elk blood. Crystals of hemoglobin were prepared from both dried blood stains of known elk and that of the unknown stains. Plate 3 compares the photomicrographs of crystals obtained from known elk blood with crystals obtained from the blood stains on the cloth found in the car of the defendant. Crystals A-1 and B-1 are from known elk blood while crystals A-2 and B-2 are from the unknown.

The crystals of the known and unknown are alike and fit the original description for hemoglobin crystals of the wapiti. A technical study of the crystals of the known and unknown was made by Professor Carl S. Gilbert, University of Wyoming, who stated that the crystals fit the technical description of the hemoglobin crystals of *Cervus canadensis* as given by Reichert and Brown. Hemoglobin crystals from the domestic cow and the jack rabbit were also prepared and examined, and compared with those of the elk. These crystals were markedly different from those of elk.

CONCLUSIONS

From the limited studies presented here, it now appears that a transmission spectrum or absorption spectrum of whole blood or blood stains has less promise of being of use in the identification of unknown blood stains. The methods of Reichert and Brown for crystallizing hemoglobin are good, and if crystals of the hemoglobin can be obtained, there is no question of identity.

This manner of crystallizing hemoglobin is satisfactory for whole bloods. The application of the method for the identification of blood stains is limited because a sufficient quantity of hemoglobin must be obtained to make a heavy solution of the hemoglobin, and further, there must not be a great deal of contamination from oils or dust. If crystals of hemoglobin from blood can be obtained, the identification of the animal can readily be made to the genus, and it would seem that in most cases it could be made even to the species.

Reichert and Brown have conclusively shown that animal hemoglobins are not identical, and that their peculiarities are of positive generic specificity and much more sensitive in their differentiations than the precipitin tests.—KENNETH B. WINTER and RALPH F. HONESS, *Wyoming Game and Fish Commission, Cheyenne, Wyoming.*

Accepted for publication March 14, 1951.

BEARDED GRAINS CAUSE DEATH OF DEER[1]

Numerous mule deer were dying along the Hoback River at Bryan Flat, Wyoming, during February of 1949. This group of deer were being fed hay and concentrates as a winter emergency feeding procedure. Therefore, it seemed unlikely that the cause of death was a result of malnutrition.

About 30 deer had already died, and there were several sick animals in the vicinity. There was a total of approximately 250 deer wintering in this immediate area.

On investigation it was noted that the deer had been and still were feeding at wheat hay stacks and in one instance were eating wheat hay which was stacked near a chicken house at a cabin camp. A few deer had ready access to this stack, as the owner of the camp enjoyed having the deer about the premises. The greater part of the carcasses were in the vicinity of this particular stack.

The wheat hay (Plate 4A) from spring seed-

[1] Contribution from Federal Aid in Wildlife Restoration Act Project 33-R, Wyoming.

ing was of the bearded variety. It had been cut after the kernels were well formed and the beards long and stiff.

The dead animals were of both sexes and of all ages. They had died with their heads drawn back. All appeared to be in poor flesh, but this condition was not attributed to starvation. On opening the mouths, tufts of wheat beards were found embedded in the lips; between the lips and the dental pad of the upper jaw; between the teeth and the gums; and beneath the tongue on either side. (Plate 2B) The tufts of beards were deeply embedded, some beards as much as one inch.

In all animals the rumen was filled with slightly chewed wheat hay. Many entire beards of wheat were seen. There were in some cases small hemorrhages beneath the serosa over the posterior blind sacs. The mucosa of the rumen, reticulum, and omasum appeared normal. The mucosa of the abomasum and the upper four or five feet of the intestine showed a high degree of inflammation indicating a severe gastritis and enteritis. The remainder of the intestine appeared normal.

In two animals both the peritoneum and pleura showed red areas and red streaks. By following along these streaks it was possible in many cases to find parts of wheat beards. This was especially true in lung tissue since the resistance of the beards could readily be felt through the soft tissue beneath.

Postmortem changes had been so great that little could be learned from microscopic study. Sections from the abomasum further indicated there had been an acute gastritis. A piece of the beard was seen in the muscle wall of the abomasum. There was no inflammation about the beard which indicated it had been moving rapidly in this tissue.

Because these deer had numerous tufts of beards embedded in their lips and gums, they were unable to chew the bearded grain properly. Yet they continued to feed and as a result entire heads of wheat, including the beards, were swallowed. This material produced a severe gastritis and enteritis. A few beards had penetrated the stomach and intestinal walls and set up an inflammation of the body cavities which caused the death of the deer.

This is another of many man-made hazards with which wildlife is unable to cope, and it is hoped that those people who live in areas frequented by game be encouraged to grow beardless grains when they intend to cut the grain for use by livestock.—KENNETH B. WINTER and RALPH F. HONESS, *Wyoming Game and Fish Commission, Cheyenne, Wyoming.*

Accepted for publication March 14, 1951.

SELECTIVITY OF MIRROR TRAPS

In live-trapping male ruffed grouse in Pennsylvania, Tanner and Bowers (Journ. Wildl. Mgt. **12**: 330–331, 1948) reported the successful use of a wire box-trap with a mirror placed in the rear.

In connection with animal population studies on the two farms of the Wildlife on Agricultural Lands Project at the Patuxent Research Refuge, Laurel, Maryland (the writer was formerly a Research Collaborator, U.S. Fish and Wildlife Service) a trapping program was carried out, with emphasis on the farm and furbearer mammals. The traps that were used are modifications of the old Biological Survey cat-trap and are described by Stuewer (Ecol. Monographs **13**: 203–258, 1943). The modification is very adaptable and has been used successfully for catching rabbits, woodchucks, skunks, and most of the other medium-sized mammals.

Mirror-traps were constructed by fitting the glass into a frame, then placing it in the back, facing the front. Eight traps were fitted with the mirrors.

A pair of traps (one with mirror, one without) were placed at good locations on the two farms. Any animal entering the vicinity would have an equal chance to choose either type. Ear corn and smoked herring were used as bait in both traps.

A total of 1300 trap days were recorded, or 650 for each type. The operating period extended, intermittently, from March 25, 1948 to June 1, 1949, the animals usually being

checked and tagged each morning. Occasionally, in cold or hot weather, they were also examined in the afternoon. During the entire trapping period, a total of 21 mirror-traps were sprung (i.e. the trap door had dropped but no animals were caught) as compared with 27 of the other type.

Table 1 shows rather conclusively that birds are attracted by the mirror-traps. The preponderance of records in favor of birds appears to be almost entirely the reaction of cardinals. Trapping records show that cardinal males were caught in better than a 3–1 ratio, with several of the males repeating from two to five times. Of the total catch of 52 cardinals, 38 were caught in the spring breeding season. However the main trapping effort was also confined to this period, with 500 of 1300 trap days recorded between April 1 and June 30.

Mammals showed little, if any choice of traps. Several species of the mammals listed are nocturnal in their habits. Catches of the nocturnal species were apparently more the result of chance than selectivity of either trap. The mirrors would have little attraction during the night.

In view of the results of this experiment, persons interested in bird trapping might consider the use of mirrors on an experimental basis.—ROY A. GRIZZELL, JR., *School of Natural Resources, University of Michigan.*

TABLE 1.—TABULATION OF TRAPPING RESULTS

Species	Total Catch Mirror-trap	Plain-trap
Birds		
Bobwhite quail	0	2
Mourning dove	1	0
Crow	2	1
Carolina wren	1	0
Cardinal	47	5
Towhee	3	0
White-throated sparrow	1	2
Song sparrow	1	0
Chicken	1	1
Total	57	11
Mammals		
Raccoon	0	2
Long-tailed weasel	1	1
Skunk	2	0
House cat	0	1
Woodchuck	6	12
Chipmunk	3	3
Gray squirrel	10	7
White-footed mouse	9	5
Meadow vole	4	3
Pine vole	1	2
House rat	0	1
House mouse	5	3
Cottontail rabbit	7	8
Total	48	48

Accepted for publication April 24, 1951.

MOBILITY OF THE WHITE BASS, *LEPIBEMA CHRYSOPS* (RAFINESQUE)

During the course of netting studies in late September, 1950, eight white bass, *Lepibema chrysops* (Rafinesque), were captured, tagged, and released in the Kentucky River at Tyrone, Kentucky. Tag number 169 was placed on a fourteen inch white bass which was released on September 27th. On October 10th, a fisherman reported catching a white bass bearing this tag in Benson Creek, about 200 yards above the mouth of the creek at Frankfort. The distance between the point of release and the point of re-capture was twenty miles, revealing a downstream travel rate of twenty miles in thirteen days. Furthermore, the fish had gone over one navigation lock-and-dam during its movement.

The white bass is a very mobile species, especially during the spawning season, but this record is notable for the rate of travel and the season of occurrence. A search of the literature failed to reveal a comparable record. Miller and Bryan (The Harvesting of Crappie and White Bass in Wheeler Reservoir, Alabama. Journ. Tenn. Acad. Sci. **22**(1): 1947) reported a movement of twenty miles in twenty-nine days during early spring. This is the only similar instance noted.—HAROLD L. BARBER, *Biologist, Kentucky Division of Game and Fish, Frankfort, Kentucky.*

Accepted for publication April 9, 1951.

CONSTITUTION AND BY-LAWS OF THE WILDLIFE SOCIETY

CONSTITUTION

Article I—Name

The name of this Society shall be The Wildlife Society.

Article II—Objectives

The principal objectives of the Society shall be: (1) Establishment of professional solidarity and the maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; (3) publications to effect these ends; and (4) protection of the interests of its members.

Article III—Membership

Section 1. The membership of this Society shall consist of Members, Life Members, and Honorary Members.

Section 2. Membership shall be open to all persons interested in wildlife management.

Section 3. Any person may become a Member upon the recommendation of two Members and acceptance of the Secretary.

Section 4. Honorary Members shall be persons who, upon a two-thirds vote of the Council and a two-thirds vote of the Members present at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management.

Section 5. All classes of Members shall be entitled to vote, to hold office, to represent the Society officially when so appointed by the President or the Council, and to receive the Journal and such other publications of the Society as the Council may direct.

Section 6. The majority of those voting will determine the results of any election or other balloting.

Section 7. Any member may become a Life Member by paying the sum of $100.00, either as a lump sum or not less than $25.00 per year over a period not to exceed four years. Such money will be deposited in the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

Article IV—Officers

Section 1. The officers of the Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Section 2. The officers shall be elected annually by mail ballot except as noted below. The President and Vice-President shall serve until the end of the annual meeting of the calendar year following their election and shall be eligible to succeed themselves for a period not to exceed a total of three consecutive terms of one year each. The Secretary shall be elected to take office in each odd numbered year and shall serve until the end of the annual meeting in the next odd numbered year. The Treasurer shall be elected to take office in each even numbered year and shall serve until the end of the annual meeting in the next even numbered year. Before June 1, the President shall appoint a Nominating Committee of five members. Before September 1 of that year the Nominating Committee shall submit to the Secretary two available Members as nominees for each office to

be vacated. The Committee's nominations shall be published in the next October issue of the Journal of Wildlife Management or Wildlife Newsletter. Within 30 days of the date of mailing of this issue the names of additional available nominees for any office to be vacated may be submitted by any voting member in good standing and any nomination will be valid if supported by 5 per cent of the voting membership. The Secretary shall then mail to all members an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days shall be allowed for the election ballots to be returned to the Secretary. The nominee receiving the largest vote for each office shall be declared elected. In case of a tie, the decision shall be made by a majority of the Council. The outgoing President shall appoint a three-member committee within thirty days after the election to audit the nomination and election ballots. The auditor's report on balloting shall be published in The Journal of Wildlife Management or Wildlife Newsletter.

Section 3. The President shall preside at meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, except the Membership Committee, including those established by the Council, and perform other duties incident to his office.

Section 4. In the absence of the President or in his inability to act, his duties shall be assumed by the Vice-President. In the event neither one can serve, the Council shall appoint a President pro-tempore.

Section 5. The Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings of the Society. A report covering his activities during the preceding year shall be made by him to the Society at its annual meeting.

Section 6. The Treasurer shall be responsible for all funds of the Society except permanent funds held in trust and shall be bonded in suitable amounts as decided by the Council and at the Society's expense. His accounts shall be audited at the close of each fiscal year as directed by the President before presentation at the annual meeting of the Society.

Section 7. Vacancies among the officers shall be filled by vote of the Council from among the Members for the unexpired term of the office or until the next regular election.

Section 8. The Council, by a two-third vote, may combine the offices of Secretary and Treasurer into one office entitled the Executive Secretary. The Executive Secretary shall be appointed by a two-thirds vote of the Council. The Council may pay him a salary and expenses at its discretion and within sound financial limits of the Society. The Executive Secretary shall carry out the duties and make reports as specified in Sections 5 and 6 of this Article. The combining of the offices of Secretary and Treasurer shall take place at the end of the annual meeting, of same year, and a notice of such a union shall be made to the membership at least six months prior to the change. The Council, by a two-thirds vote, may eliminate the office of Executive Secretary, if conditions warrant, and restore the separate offices

of Secretary and Treasurer, and have these offices filled according to Section 2 of this Article. A petition, having at least 10 per cent of the signatures of Members will be sufficient to require the Council to submit to the voting membership for approval or disapproval of appointment or discharge of an Executive Secretary.

ARTICLE V—COUNCIL

Section 1. The Society shall be governed by a Council, composed of the President, Vice-President, Secretary, Treasurer, out-going President, and at least one representative from each of the Regions as defined in the By-Laws. The Regional Representatives shall be elected annually, shall be eligible for re-election, and shall take office at the end of the annual meeting following their election.

Section 2. The Council shall appoint the Editor; shall have power to fill vacancies occurring in its numbers; shall recommend to the Society for action, By-Laws not inconsistent with this Constitution and shall perform such other duties as are herein prescribed. Not less than one-half of the Members of the Council shall constitute a quorum. In case a Council member is unable to attend, he is authorized to appoint a qualified member as an alternate as his official representative on the Council providing he has so notified the President prior to the meeting.

Section 3. If the offices of Secretary and Treasurer are combined into an office of one person, entitled Executive Secretary, an appointee, the Executive Secretary shall not vote on Council affairs.

ARTICLE VI—MEETINGS

Section 1. Unless the Council directs otherwise, the Society shall hold an annual meeting. The Council may direct that other meetings be held at places and dates selected by them. Due notice of such meetings shall be given by the Secretary at least thirty days in advance.

Section 2. Resolutions proposed for consideration at any meeting of the Society must first receive approval of the majority of the Council, and if subsequently approved by the majority of the members attending the Society meeting, such resolutions shall represent the official view or recommendations of the Society.

ARTICLE VII—SECTIONS

Sections of the Society may be authorized by the Council upon petition of ten or more Members. Sections may adopt necessary By-Laws, providing that no part of them shall conflict with the Constitution of this Society. A report of its activities shall be presented by each section at the annual meeting of the Society.

ARTICLE VIII—DUES AND FUNDS

Section 1. The annual Membership dues shall be $5.00. Subscriptions shall be $5.00 beginning with Volume 12. No dues shall be charged Honorary Members.

Section 2. Annual dues shall be payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall receive no publications until such dues are paid.

Section 3. All monies accruing to the Society received for undesignated pur-

poses shall constitute the Permanent Trust Fund, the proceeds from which shall be utilized to carry forward the work of the Society as directed by a three-fourths vote of the Council. In the absence of such direction, this income shall be reinvested by the Trustees.

Section 4. Bequests, grants or trusts made for the purpose of advancing the field of wildlife management and/or The Wildlife Society may be accepted by the Society, providing the Council shall have first favorably considered the objects and specifications set up by the trust. These shall be placed in the Permanent Trust Fund.

Section 5. The Permanent Trust Fund of the Society shall be controlled in trust by a board of three Trustees with power to sell and reinvest according to their judgment. One Trustee shall be elected at each annual stated meeting for a term of three years. In case of vacancies caused by suspension, resignation or death, successors shall be appointed by the Council for the remainder of the term. The Trustees shall be bonded in suitable amounts as directed by the Council and at the Society's expense.

ARTICLE IX—AMENDMENTS

The Constitution may be amended by a two-thirds vote of the Society Members who return ballots in response to a notice of the proposed amendment. Such notice must be submitted to all Members at least thirty days previous to the closing date for the receipt of ballots. Amendments may be referred to the Society for action either by a two-thirds vote of the Members at any stated annual meeting, or by a favorable vote of at least two-thirds of the Council.

BY-LAWS

I. ELECTION OF OFFICERS

Election of officers shall be made by mail ballot as specified by the Constitution.

II. ELECTION OF COUNCIL

Representatives to the Council shall be chosen, one from each region, as follows: The Regional Representative for each Region shall be nominated and elected annually by mail ballot by members residing in each Region. Nomination ballots shall be mailed to all members by the Secretary by August 1, each year. Each member may nominate three qualified persons residing in his region as his first, second, and third choices for representative from that Region. Thirty days will be permitted for members to return their ballots. After the 30-day time interval, the Secretary will tabulate the results. The members' first choice will receive 3 points; second choice, 2 points; and third choice, 1 point. The two nominees receiving the most votes within each Region shall be listed on the annual election ballot for Society officers. The nominee for Regional Representative who also is nominated as an officer shall be placed on the ballot only for the officer position and the nominee for regional representative holding the next largest number of votes shall be substituted for him on the ballot. Regional Representatives shall be eligible for reelection and shall take office at the end of the annual meeting following their election. The Regions shall be as follows:

Region 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island,

Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, and West Virginia.

Region 2: Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

Region 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

Region 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

Region 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

Region 6: Washington, Oregon, California, Idaho, Nevada, Utah, Alaska, and Hawaii.

Region 7: Canada.

Additional Regions may be established for similar representation upon approval by the Council.

III. Order of Business

The order of business at the annual stated meeting, unless changed by a two-thirds vote of the Members present, shall be as follows:

1. Reading and approval of the minutes of the previous meeting.
2. Report of the Secretary.
3. Report of the Treasurer.
4. Report of Regional Representatives and Sections.
5. Appointment of temporary committees.
6. Report and recommendations by the Council.
7. Action on business reported by the Council.
8. Reports of committees.
9. New and unfinished business.

IV. Delinquents

A member shall be dropped from the annual list of members after becoming one year in arrears of dues. A member shall be reinstated upon payment of dues for the current year in which application is made.

V. Fiscal Year

The fiscal year of the Society shall end the last day of February.

VI. Editor

The Editor shall be appointed by the Council. He shall serve for one year, or until his successor is appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council.

VII. By-Laws

By-Laws may be adopted, amended or repealed at any annual meeting by a majority vote of the Members present.